Houston/Galveston National Weather Service

2006 Hurricane Workshop

Katrina and Rita

LESSONS LEARNED FOR THE NEXT TIME

Presented by

CenterPoint® Energy

Welcome

Welcome to the 2006 Houston/Galveston Area Annual Hurricane Workshop. The purpose of our workshop is to increase public awareness of the hurricane hazards for our area and to give citizens useful information on how to prepare for and respond to a landfalling hurricane.

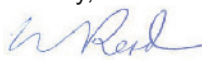
We would like to thank the City of Houston for providing the George R. Brown Convention Center for the workshop. After the record breaking and history changing 2005 Hurricane Season, we suspect interest in attending workshops such as ours will be much higher than in previous years. The added capacity and centralized location of the George R. Brown gives us the ability to accommodate a larger audience than in past years.

We are excited to have CenterPoint Energy again this year as our financial sponsor. CenterPoint Energy has a major stake in the response and recovery from a hurricane and a long history of community service. From educational improvement initiatives, to financial support for worthy causes, to reconstruction projects for the elderly and fixed-income senior citizens, to sponsorship of some of this area's premier celebrations, CenterPoint Energy and their employees are leaders – and doers. CenterPoint serves customers in eleven states and tailors outreach programs to meet the varying needs of our unique communities. Last year, CenterPoint Energy volunteers and their family members contributed over 110,000 community service hours, representing a cash value of over $1.8 million to the community.

Each year, we focus on an important aspect of hurricane preparedness or look at lessons learned from significant events from the previous season. This year, the lessons learned from two of the major storms to hit the U. S. Gulf Coast, Katrina and Rita, will be showcased. With loss of life from storm surge in excess of 1000 and economic losses approaching $100 billion in Louisiana and Mississippi, similar serious issues regarding evacuation and hurricane preparedness face the Houston/Galveston area. Our speakers will reflect on important aspects of these storms while our break out sessions will provide information on how to respond to such a threat in our area. We hope you find the workshop informative and helpful.

Thank you for attending!

Sincerely,



Bill Read
Meteorologist in Charge
Houston/Galveston National Weather Service

Acknowledgements

An event and booklet such as this can only take place because of the hard work and long hours of dedicated service of the many employees of the Houston/Galveston National Weather Service.

The National Weather Service would also like to thank the Harris County Homeland Security and Emergency Management office for providing additional financial backing and manpower resources to make this year's workshop a success.

Artwork on the front and back covers provided by the graphics department of CenterPoint Energy.

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Katrina and Rita - Lessons Learned?

By Bill Read
Meteorologist in Charge

The historic 2005 Atlantic Hurricane Season will undoubtedly provide years of research on lessons learned from many of the storms. For this conference, we have chosen to focus on some of the lessons learned to date from two of the major hurricanes which impacted the U. S. Gulf Coast – Katrina and Rita. It should be noted that as of this writing, we feel only the tip of the iceberg has been studied concerning these two major events. As such, we expect conclusions reached now may likely be challenged and changed once the benefit of time adds to the research.

Katrina provided meteorologists, emergency managers and social scientists the catastrophic event they have been warning of for at least the past three decades. This group has been preaching, probably to deaf ears, that the era of hurricane deaths over 1000 had not passed in the last century. The "sermon" went something like this: given the huge population at risk, it is only a matter of time before a large and powerful hurricane made landfall in a vulnerable region causing great loss of life in addition to the large loss of property. One of the most vulnerable areas was said to be the central Gulf Coast region including southeast Louisiana and Mississippi. Thus, the first lesson learned from Katrina is that a large loss of life (more than 1300 in the case of Katrina) can happen when a major hurricane strikes the coast of the United States. The Houston/Galveston/Golden Triangle area is another highly vulnerable location.

The vast majority of fatalities from Katrina occurred due to drowning in flood waters caused either directly due to the surge or indirectly due to the levee failures in New Orleans. Studies on why the levee failures occurred are incomplete but one thing is certain – they would not have failed if not for the surge from Katrina. The surge from extreme eastern Louisiana eastward across the Mississippi coast was huge – reaching over 25 feet in some locations. This was expected and is not without precedent. Hurricane Camille provided a similar disaster on the Mississippi coast in 1969. For New Orleans, as bad as this disaster was, it would have been much worse had Katrina come inland just some 30 to 50 miles further to the west. The surge would have been much greater, levee failures more widespread and rapid, and flooding more catastrophic. The result would have been many more people trapped at the peak of the storm with no means of escape or rescue.

Evacuation from the surge zone is the proven way to avoid loss of life from landfalling hurricanes. An estimated 80% of the people living in the area flooded by Katrina evacuated. If substantiated by further study, this was actually a "good" evacuation, as other recent storms have showed less (sometimes much less) than 80% compliance with evacuation orders. In fact, just a few months later, less than 25% of the people ordered to leave the Florida Keys actually did so for Wilma. The problem with an 80% "good" evacuation is this: for the region impacted that left upwards of a quarter of a million people still in the surge zone. The evacuation decisions made by local officials were made in stages, starting with voluntary evacuation as early as late Friday. Mandatory evacuation orders were delayed until Saturday and in some cases as late as Sunday, this for an area with clearance times in excess of 36 hours. One of the reasons for the delay is the challenge presented to decision makers in making the call for evacuation when there is still a lot of uncertainty in the forecast. The lesson that should be learned is given the vulnerability of the population, evacuation decisions must be made well in advance despite the low probability of impact at the time the decision needs to be made.

Response to Katrina was a disaster in and of itself and will take a considerable amount of time to fully understand. It remains to be seen whether the money and political will to really be ready for the next such disaster exists. Recovery from Katrina will likely take years to accomplish and we will have the opportunity to learn lessons along the way on how to handle a large catastrophe.

Hurricane Rita presented the almost unheard of challenge of a second large major hurricane in the Gulf just three weeks after Katrina. Rita was eerily similar to Katrina: she got organized over the Bahamas, affected Florida as a minimal hurricane, explosively deepened to record setting Category 5 status over the open waters of the Gulf, then weakened at or just before landfall. Both were large storms and coupled with the intensity over the open water, still produced a record surge at landfall in spite of lowering wind speeds. The surge from Rita was estimated between 15 and 20 feet in southwest Louisiana, which was higher than the storm of record, Hurricane Audrey (1957). Contrast this to Hurricane Charley in 2004, which intensified just prior to landfall yet produced less storm surge than its wind strength would suggest. The lesson: do not reduce the surge threat just because a big storm weakens some in the hours before landfall.

The evacuation from Rita was unprecedented. No traffic plan in place last summer called for anywhere near the numbers who fled. Depending on whose report you read, upwards of three million people in Texas fled Rita. Some 1.5 million people live in designated evacuation zones. Even if 90% of the people in the surge zone evacuated, more people evacuated from

outside the surge zones than in. The psychological impact of the just unfolding Katrina disaster undoubtedly contributed to the large number of people who fled Rita. Unlike what happened for Katrina, decision makers were not in the least reticent about calling for evacuation. Decisions were planned for more than 72 hours in advance and executed between 48 and 60 hours in advance of landfall. For the coastal communities, these decisions were made following plans developed by the emergency management community working together over the past decade. Had it not been for the unprecedented evacuation by people living well outside the evacuation zones, the process would likely have been deemed a success. However, gridlock on the roads led to much suffering and more fatalities than from the hurricane itself. Officials had planned on a phased evacuation. People ignored the plan and left almost at the same time. Is there any realistic way to get people to go in phase? A successful traffic management plan depends largely on the ability of officials to estimate how many people will evacuate and when the evacuation will occur.

Big questions remain for the next time an evacuation is called. Will so many people living outside the surge zones evacuate? Or will many people who suffered in gridlock reach the conclusion that it would be better to stay next time? For people inland from the surge zone, preparing and staying could be a worthwhile decision. For people in the surge zone, it could spell tragedy.

What other lessons can or should we take from Katrina and Rita?

Most citizens do not prepare for disaster: we do not stockpile non-perishable food and water in advance of the hurricane season, we do not have the materials on hand to protect windows or do mitigation repairs, and we do not have a clearly thought out plan for what we will do if a hurricane approaches, etc. When confronted with the prospect of going without power, food or water for days or weeks, a logical choice would be to flee. Add the three weeks of viewing tragedy in the wake of Katrina in Louisiana and Mississippi, is it a big surprise that the first response for millions was to flee? For people living in the surge zone, this was not necessarily a bad response. Had Rita made landfall only 80 miles west of where she did, 15 to 20 foot above normal tides would have inundated the homes of upwards of 500,000 people. For those of us in the surge zone, our only logical plan is to evacuate. Is there any reason to expect citizens to be better prepared the next time? If the next time is this year or the next, than maybe the answer is yes. What about ten or twenty years from now?

Development continues unabated in the surge zone (Figure 1 on page 4). The lesson learned here is that we either do not understand or choose to ignore the threat. On the plus side, building codes have improved to help structures withstand the wind, but are still only certified up to Category 3 for coastal counties and less for the next tier in. In spite of very specific studies done by Harris County and Texas Department of Emergency Management over the past five years that clearly show the degree of potential for storm surge flooding in the Houston/Galveston/Brazoria area, nothing has changed as far as development goes. Given the lessons of the past two hurricane seasons, does this policy make sense?

It is estimated that perhaps 50 percent of the citizens flooded by Katrina or living in areas of potential storm surge along the upper Texas coast do not carry flood insurance. Why? My guess is that they, their elected officials, lenders, and sadly, many insurance agents do not understand the fact that the storm surge threat covers most of the area. The 100 year flood plain that the flood insurance program is based on is only a small percentage of the area threatened by surge. Lenders only require flood insurance for property in the 100 year flood plain. For example, I was required by my lender to have windstorm insurance on my house in Galveston County but not flood insurance, even though the slab elevation was only 14 feet. Does that make sense? Ask someone in Mississippi who is fighting with the insurance company over claims on whether the destroyed property was damaged due to wind or water.

Lastly, a common theme in our work toward hurricane preparedness is that advances in science and technology will lead to a reduction in loss. In spite of extensive preseason planning, good to excellent forecasts and warnings, and continuous news coverage to the advancing storms, we still see huge economic losses; and now with Katrina, large human losses. Lesson learned – we have a long way to go.

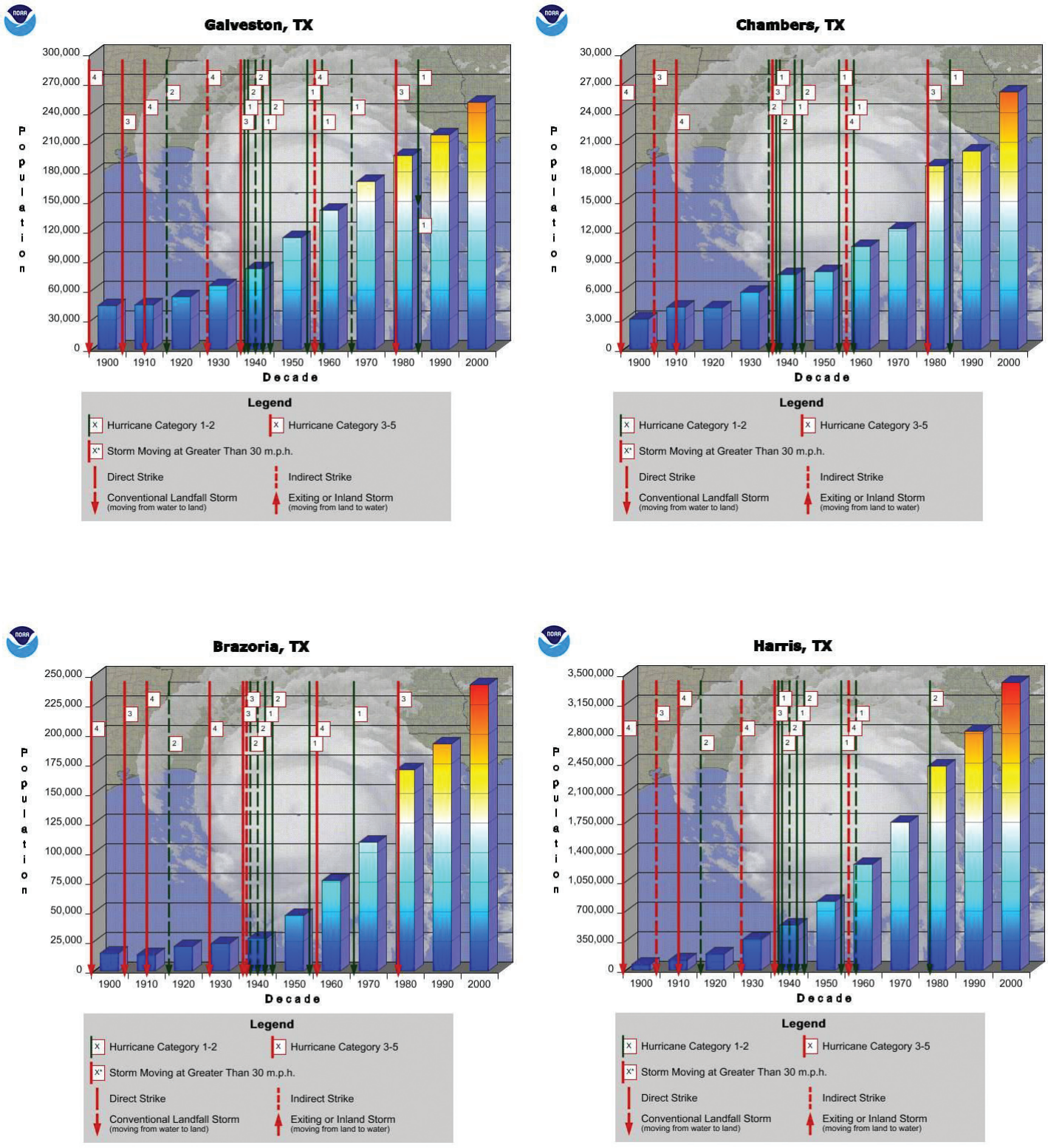

Figure 1: Population growth in Galveston, Chambers, Brazoria and Harris Counties by decade. Note that the majority of this growth occurred during a recent lull in hurricane activity. Source: NOAA Coastal Services Center.

Katrina and Rita
Development, Track and Major U.S. Effects

By Lance Wood

Hurricane Katrina

Katrina has replaced Hurricane Andrew (1992) as the costliest U.S. natural disaster and is the deadliest since a devastating storm surge took approximately 2500 lives during the 1928 Okeechobee Hurricane. The catastrophic flooding in New Orleans alone displaced more than 250,000 people, the greatest single displacement of Americans to occur since the Dust Bowl years of the 1930s. What follows is a brief summary of Katrina's genesis, demise and meteorological impacts.

The meteorological birth of Katrina occurred on the afternoon of August 22nd, when an upper level trough weakened as it moved westward toward Florida. This weakening allowed winds in the upper portion of the atmosphere to relax sufficiently for a tropical disturbance to organize into a tropical depression over the southeastern Bahamas, approximately 200 miles southeast of Nassau. This depression was designated Tropical Depression Twelve, with advisories from the National Hurricane Center initiated at 5 PM EDT on August 22nd. The depression strengthened while moving northwest through the Bahamas becoming Tropical Storm Katrina at 11 AM EDT on August 24th. Katrina attained Category 1 hurricane status less than two hours before making landfall late in the evening on the 25th between Miami and Ft. Lauderdale. The NWS Miami Doppler radar showed the well defined eye and convective pattern of Katrina as she moved west-southwest across the southern Florida Peninsula (Figure 1). The convective pattern was rather asymmetric due to northerly wind shear, which placed

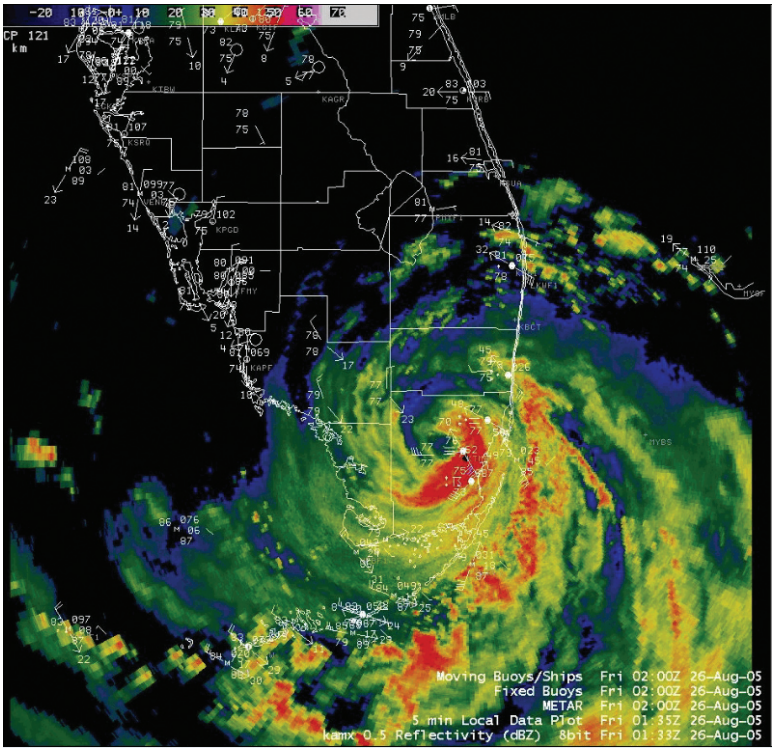

Figure 1: Radar reflectivity image from the NWS Miami Doppler Radar of Hurricane Katrina while over southern Florida.

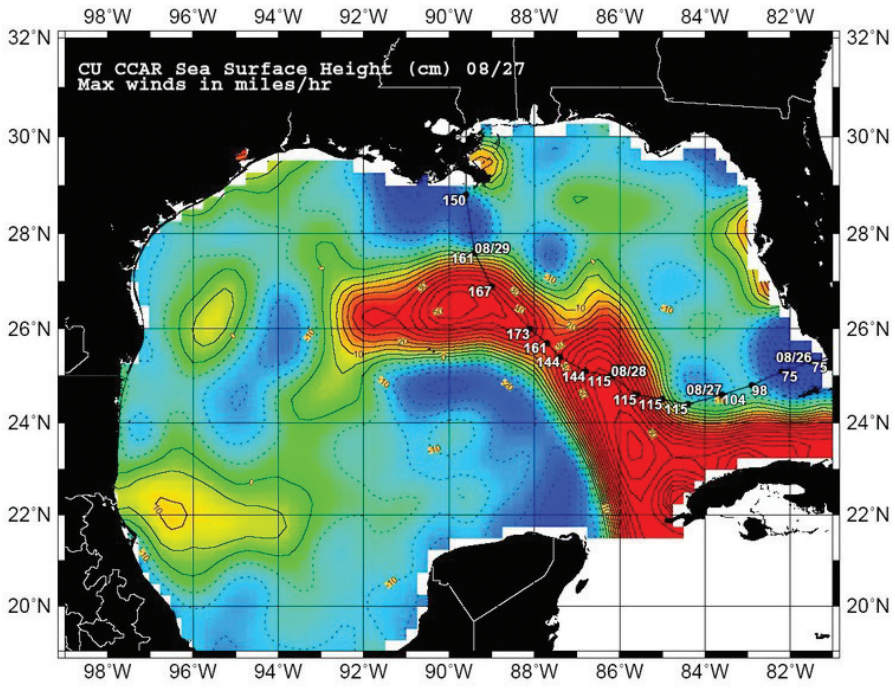

Figure 2: Wind speeds of Hurricane Katrina increasing as she passes over the warm waters of the Gulf of Mexico's Loop Current (Image from the University of Colorado at Boulder).

the strongest winds and heaviest rains south and east of the center in Miami-Dade County. Katrina caused widespread damage with 80 to 90 mph wind gusts as she moved across south Florida. The cyclone dropped 10-15 inches of rain across southern portions of Miami-Dade County which produced significant flooding. Katrina spent approximately six hours over Florida and emerged into the Gulf of Mexico around 1 AM EDT on August 26th, as a strong tropical storm.

Over the warm waters of the Gulf of Mexico, Katrina quickly regained hurricane status just an hour later. The center of Katrina continued west-southwest over the southeastern Gulf of Mexico and away from the southern Florida Peninsula. However, an outer rainband containing tropical storm force winds pummeled much of the Florida Keys on August 26th. Sustained hurricane force winds were briefly measured at Dry Tortugas on the far western end of the island chain that afternoon. While moving west across the Gulf, Katrina encountered ideal conditions for tropical cyclone intensification due to very warm water within the Loop Current (Figure 2) and favorable

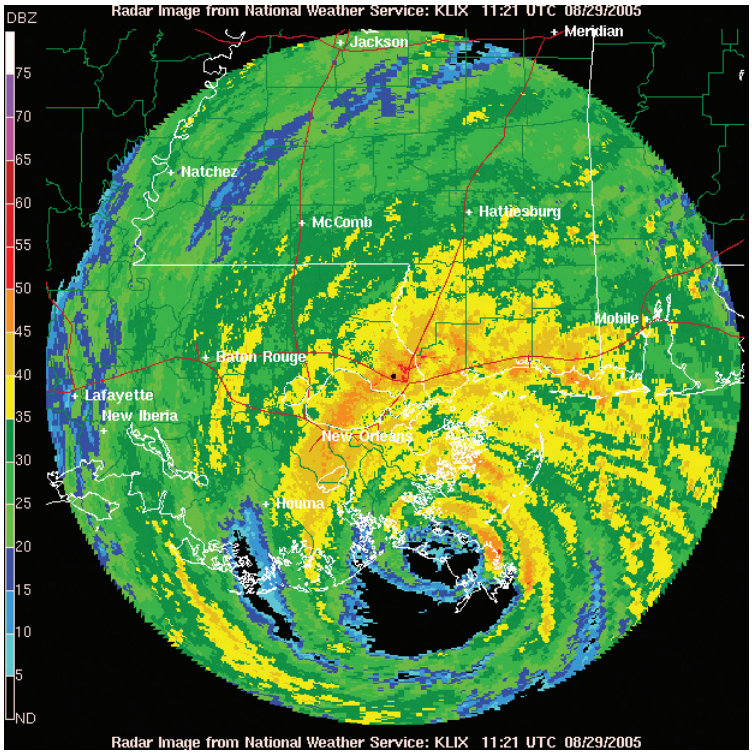

Figure 3: Radar reflectivity image of Hurricane Katrina near landfall from the New Orleans Doppler Radar.

upper level winds because of a mid to upper level high pressure system situated overhead. On August 27th and 28th, Katrina grew into a huge and extremely powerful hurricane. While strengthening to a Category 3 hurricane she doubled in size on August 27th, with the radius of tropical storm force winds reaching 160 miles. Katrina then strengthened from a low-end Category 3 hurricane to a Category 5 hurricane in less than 12 hours, reaching an intensity of 170 mph by 7 AM CDT on August 28th. Katrina attained a peak intensity of 175 mph later that afternoon about 200 miles southeast of the mouth of the Mississippi River. The wind field also continued to grow on the 28th, with the radius of tropical storm force winds reaching 230 miles and the radius of hurricane force winds reaching close to 105 miles. Fortunately, Katrina did not retain this Category 5 strength for long, as she weakened significantly while moving north toward the Louisiana coast. Katrina moved over slightly cooler waters, went through an eyewall replacement cycle, experienced increasing wind shear and may have entrained drier air into her circulation pattern. It is likely the combination of these factors which led to Katrina's weakening before landfall and resulted in estimated maximum wind speeds of 125 mph, making Katrina a high end Category 3 hurricane at landfall in far southeastern Louisiana (near Buras) during the early morning hours of August 29th. The eye continued northward over the Gulf of Mexico and reached the coastline a second time near the Louisiana/Mississippi border remaining a Category 3 storm with winds near 120 mph. See Figure 3 for a radar representation of Katrina near landfall.

Katrina's landfall along the northern Gulf Coast was devastating to an area that extended from southeastern Louisiana to Mobile, Alabama. Category 3 wind speeds affected a large area between Bay Saint Louis and Biloxi, Mississippi. Wind gusts of 80 to 90 mph were measured as far east as Mobile, Alabama. Katrina produced a significant storm surge from southeastern Louisiana to the Florida Panhandle, along and east of where the eye made landfall. It appears to have been as high as 27 feet at Hancock, Mississippi at the Mississippi Emergency Operations Center. Because many buildings across coastal Mississippi

Figure 4: Before and after images of Biloxi, MS, showing the impact of the catastrophic surge from Hurricane Katrina (USGS).

Figure 5: Flood waters in New Orleans after failures of the levee system. (Image from National Hurricane Center)

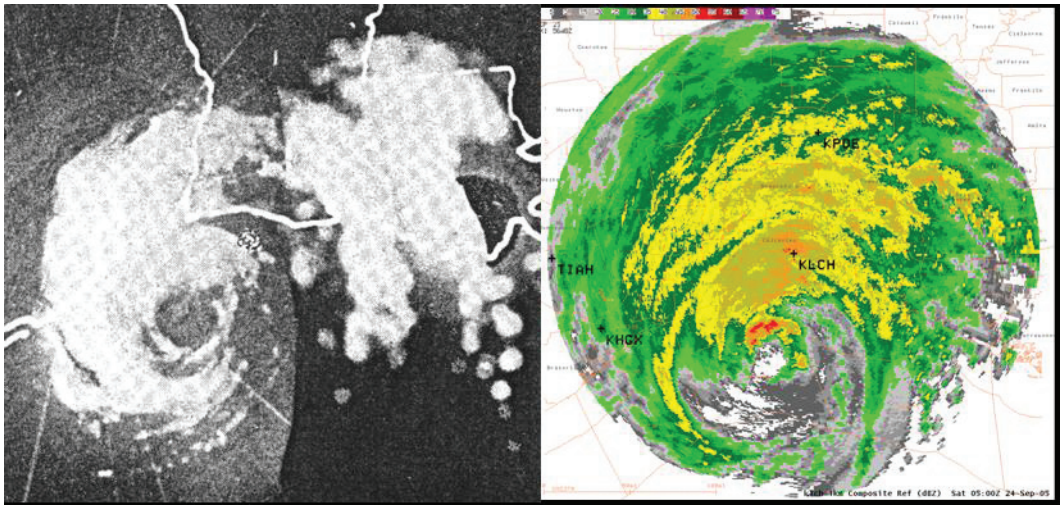

Figure 6: Radar reflectivity images of Hurricane Audrey (1957) (left) and Hurricane Rita (right).

were totally destroyed, high water marks were difficult to obtain during the post-storm assessment. The surge did reach a height of 10 feet as far east as Mobile, Alabama. The combination of the storm surge and 120 mph wind speeds caused extreme damage along the coast. See Figure 4 for before and after photos of Biloxi, Mississippi.

A day after landfall, flooding became the most devastating event associated with Katrina. The surge caused the water level of Lake Pontchartrain to rise, straining the levee system protecting New Orleans. Significant failures of the levee system began to occur on August 29th and resulted in breaches that allowed water to pour into New Orleans, a city which sits below sea level. The levee breaches left 80% of New Orleans under water with depths of up to 20 feet at some locations (Figure 5). It is this flooding of New Orleans that will be Katrina's legacy and what made this hurricane unique and so devastating when compared to other major U.S. landfalling hurricanes.

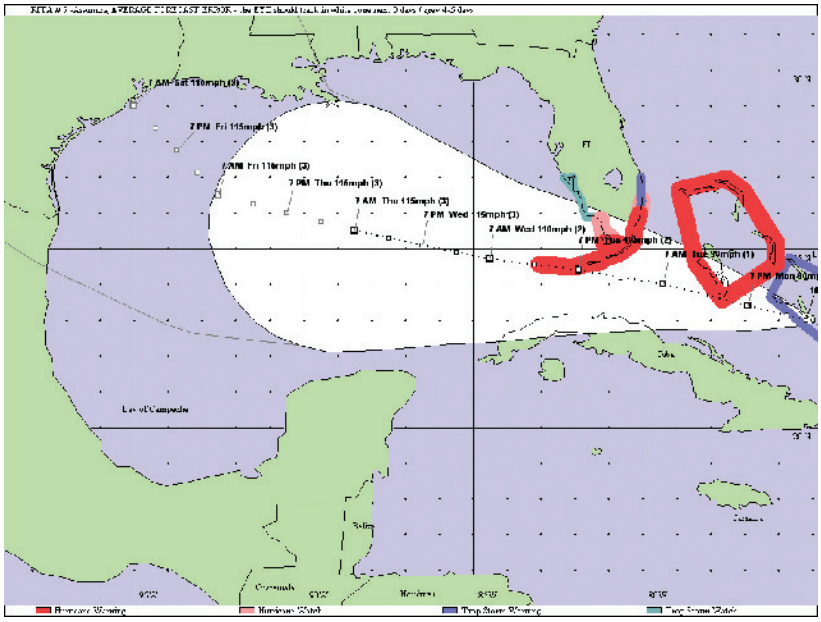

Figure 7: HurrEvac image of the National Hurricane Center forecast and 10 year average error cone from the 4 AM CDT advisory on Monday, September 19th, 2005 (Hurricane Rita).

Hurricane Rita

Hurricane Rita was the second Category 5 hurricane to occur in the Gulf of Mexico during 2005. She was also the most intense Gulf of Mexico hurricane on record having reached a minimum central pressure of 897 mb, surpassing 1980's Hurricane Allen (899 mb). The 2005 season marked the first occurrence on record of two hurricanes reaching Category 5 strength in the Gulf of Mexico in the same season. Hurricane Rita is the 6th costliest U.S. hurricane. Amazingly, the hurricane was only responsible for seven direct deaths. However, it should be noted that over 55 deaths resulted indirectly from the hurricane, many during an unprecedented evacuation of an estimated three million Texas and Louisiana residents. Hurricane Rita was the strongest hurricane to make landfall across extreme southwest Louisiana since Hurricane Audrey (1957). See Figure 6 for a comparison of Audrey and Rita. What follows is a brief summary of Rita's life cycle and significant U.S. effects, beginning with her formation and ending just after her landfall near the Texas/Louisiana border.

Rita formed just three weeks after Hurricane Katrina made her final landfall along the northern Gulf Coast. With Katrina still fresh in the minds of Gulf Coast residents, all eyes turned to the Bahamas once again as another tropical disturbance began to organize. The primary meteorological features that led to the development of Rita were the presence of an old frontal boundary, convection associated with an upper level low pressure system, and a tropical wave. The complex interaction of these features allowed surface low pressure to gradually develop over a two-day period. Tropical Depression Eighteen formed just east of the Turks and Caicos Islands on September 17th. The depression quickly became Tropical Storm Rita, the 17th named storm of the season, at 5 PM EDT on September 18th. Rita took a more southern route through the Bahamas when compared to Katrina. However, Rita quickly intensified as she approached the warm waters of the Gulf of Mexico and began to move over the Loop Current, much like Katrina had done in late August. Rita rapidly intensified while moving west through the Florida Straits and into the Gulf of Mexico on September 20th, reaching Category 2 intensity as her center passed 50 miles south of Key West. Even though the center of Rita did not make landfall in the Florida Keys, strong winds downed trees and produced storm tides of up to five feet across portions of the island chain, flooding sections of U.S. Highway 1 and many other streets, as well as several homes and businesses.

After entering the Gulf of Mexico, Rita intensified at an astounding rate going from a Category 2 to a Category 5 hurricane in 24 hours. Following this rapid intensification period, sustained winds reached 165 mph on the afternoon of September 21st. By early Thursday morning, September 22nd, Rita had strengthened further with winds reaching a peak intensity of 175 mph and minimum pressure falling to 897 mb. This was the third lowest pressure on record at that time for the Atlantic basin, and the lowest for the Gulf of Mexico. An upper-level disturbance passing well north of Rita early on Thursday briefly induced a more northward motion and altered Rita's movement from west-northwest to northwest. Although this change in heading was only slight, it spared the densely populated Houston/Galveston area from a direct hit and shifted the forecast track and eventual landfall point to the right or east. Residents of extreme southeast Texas and southwest Louisiana were then expected to experience the brunt of Rita. Fortunately, Rita weakened to a Category 3 hurricane on Friday, September 23rd, prior to landfall, just as Katrina had done. Landfall occurred around 240 AM CDT, September 24th, just east of the Texas/Louisiana border between Sabine Pass and Johnson's Bayou.

Since early Monday (September 19th), Rita had been consistently forecast to make landfall along the upper Texas coast, when the 120 hour forecast from the National Hurricane Center depicted a landfall near San Luis Pass (Figure 7). Emergency management officials, members of the media, and residents of southeast Texas had been watching Rita closely and planning their courses of action on Monday and Tuesday. Therefore, even though the hurricane was still 620 miles southeast of Galveston, an unprecedented, largely voluntary evacuation began on Wednesday across southeast Texas. Emergency management officials had publicized well in advance that a mandatory evacuation for the storm surge zones of southeast Texas would begin at 6 PM CDT on Wednesday. However, residents waiting until then to begin their evacuation found roadways in and around the densely populated Houston/Galveston area already jammed with motorists who had left earlier in the day. The fear of Katrina-like impacts prompted many inland residents to evacuate even though they were not at risk from storm surge flooding. Therefore, an incredible number of people decided to flee Rita, with officials estimating the total to be over three million. Although the gridlock and gasoline shortages frustrated many evacuees, the evacuation had been ordered very early, and there was ample time for residents to escape the region before the onset of adverse conditions, which were expected to begin Friday afternoon.

Rita produced devastating storm surge flooding and wind damage in southwest Louisiana and extreme southeast Texas. Communities located along the Calcasieu Parish coastline in southwest Louisiana will never be the same, due to a 15 to 20 foot storm surge, which destroyed any structure in its path (Figure 8). Rita affected a large inland area from southeast Texas to south-central Louisiana. Widespread damage consisting of downed trees and power lines occurred generally along and east of a Crystal Beach to Liberty to Livingston to Lufkin line in Texas, and west of an Abbeville to Leesville line in Louisiana. Both Lake Charles and Beaumont/Port Arthur experienced significant damage as the strongest winds in the eyewall region affected both communities. Lake Charles was in the path of the eastern portion of Rita's eyewall, while Beaumont/Port Arthur was in the path of the western portion of the eyewall. Although Rita tracked approximately 50 miles east of Lake Livingston, sustained northerly winds of 40 to 60 mph occurred across the lake, generating a lake surge that damaged the dam. Fear that the dam could break forced an evacuation of communities immediately downstream as a precautionary measure. Emergency water releases from the dam on Saturday morning (24th) quickly abated this danger. Damage to the dam was estimated at $10 million.

Figure 8: Damage caused by the winds and storm surge associated with Hurricane Rita in Cameron, LA. (Image from NWS Lake Charles Staff)

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- Technical Report 2005-01 Hurricane Katrina - A Climatological Perspective, National Climatic Data Center
- Tropical Cyclone Report – Hurricane Katrina (December 2005), National Hurricane Center
- Tropical Cyclone Report - Hurricane Rita (March 2006), National Hurricane Center

2005 Hurricane Season – A Record-Breaking Year

By Joshua Licher

The 2005 Hurricane Season was one for the records. Here are a number of the many records broken during the season.

Season records include…

- 28 named storms are the most named storms in a single season, breaking the old record of 21 named storms set in 1933.
- 15 hurricanes are the most hurricanes in a single season, breaking the old record of 12 hurricanes set in 1969.
- 7 major hurricanes (Category 3 or higher on the Saffir-Simpson Hurricane Scale) are the second most major hurricanes in a season, one behind the 8 major hurricanes of 1950.
- Three Category 5 hurricanes (Katrina, Rita, and Wilma) are the most Category 5 hurricanes recorded in a single season, breaking the old record of two set in 1960 and 1961.
- Seven named storms made United States landfall (Arlene, Cindy, Dennis, Katrina, Rita, Tammy and Wilma). This puts the 2005 season in a tie for second place for landfalling storms behind the 1916 and 2004 seasons where eight named storms made landfall. An eighth 2005 storm (Ophelia) brushed the coast of North Carolina but did not make an official landfall.
- The 2005 season was the most destructive for United States landfalling storms, largely due to Hurricanes Katrina and Rita. Damage estimates are well over $100 billion.
- 2005 had two hurricanes (Katrina and Stan) that each killed more than 1000 people. The all-time record is three hurricanes in 1780.
- Five names were retired (Dennis, Katrina, Rita, Stan and Wilma). Previous record was four names in 1955, 1995 and 2004.

Monthly records include…

JUNE
Two named storms formed (Arlene and Bret). Only 1957, 1959, 1968, and 1986 had two or more named storms form during the month of June.

JULY
Five named storms formed (Cindy, Dennis, Emily, Franklin, and Gert). This is the most on record for the month.

Two major hurricanes formed (Dennis and Emily). This is the most on record for the month.

AUGUST
Five named storms formed (Harvey, Irene, Jose, Katrina and Lee). Only 1990, 1995 and 2004 have had more than five named storms form during the month of August.

SEPTEMBER
Five hurricanes formed (Maria, Nate, Ophelia, Philippe and Rita). This ties 1955, 1969, 1981, 1998 and 2000 for the most hurricanes to form during the month of September.

OCTOBER
Six named storms formed (Stan, Tammy, Vince, Wilma, Alpha and Beta). This ties 1950 for the most named storms during the month of October.

Four hurricanes formed (Stan, Vince, Wilma and Beta). Only 1950 had more hurricanes develop during the month of October.

Two major hurricanes formed (Wilma and Beta). This ties 1950, 1961, 1964 and 1995 for the most intense hurricanes to form during the month of October.

NOVEMBER
Three tropical storms formed in November (Gamma, Delta, and Epsilon). This breaks the record of two storms set in six years, most recently in 2001.

DECEMBER
Epsilon was the longest lived (5.25 days) December hurricane on record. The previous record was just over four days set by an unnamed 1887 hurricane.

JANUARY
Zeta was the longest-lived January tropical storm on record (six days). Zeta surpassed Alice (1954) as the longest-lived tropical cyclone to form in December and cross over into the new year.

Individual Storm Records...

DENNIS

- Dennis became the most intense hurricane on record before August when a central pressure of 930 mb was recorded.

EMILY

- Emily eclipsed the record previously set by Dennis for lowest pressure recorded for a hurricane before August when its central pressure reached 929 mb.

KATRINA

- Katrina recorded the greatest storm surge (27 feet in Mississippi) from an Atlantic hurricane. The previous record was 24.6 feet in Hurricane Camille (1969).
- Katrina's central pressure dropped to 902 mb. At the time, it was the fourth lowest pressure ever measured in the Atlantic basin.
- Katrina's central pressure at landfall was 918 mb. This is the third lowest pressure recorded at landfall behind the Florida Keys storm of 1935 (892 mb) and Hurricane Camille of 1969 (909 mb).
- Katrina became the most destructive storm on record with greater than $100 billion damage. This shatters the old record of approximately $50 billion (normalized to 2005 dollars) in insured damage set by Hurricane Andrew (1992).
- Katrina produced a record wave height in the Gulf of Mexico - 55 feet at Buoy 040 (64 nautical miles south of Dauphin Island, AL).

RITA

- Rita's central pressure dropped to 897 mb. At the time, it was the third lowest pressure ever measured in the Atlantic basin.

VINCE

- Vince was the furthest north and east that a storm has ever developed in the Atlantic basin.
- Vince was the first tropical cyclone in recorded history to strike the Iberian Peninsula.

WILMA

- Wilma's central pressure dropped to 882 mb. It was the lowest pressure ever measured in the Atlantic basin, eclipsing the old record of 888 mb set by Hurricane Gilbert (1988).
- Wilma had the fastest intensification ever by an Atlantic hurricane. The largest 6, 12, and 24 hour drops in best track central pressure for Wilma, 54 mb from 00 to 06 UTC on October 19th, 83 mb from 18 UTC on October 18th to 06 UTC on October 19th and 97 mb from 12 UTC on October 18th to 12 UTC on October 19th, respectively, are by far the largest in the available records for these periods going back to 1851. The previous record 6 hour deepening was 38 mb in Hurricane Beulah (September 1967), the previous record 12 hour deepening was 48 mb in Hurricane Allen (August 1980), and the previous record 24 hour deepening was 72 mb in Hurricane Gilbert (September 1988).
- Wilma had the smallest eye diameter ever measured in a hurricane – two nautical miles.

DELTA

- Delta became extratropical shortly before it hit the Canary Islands, but was the first tropical cyclone on record to affect the islands.

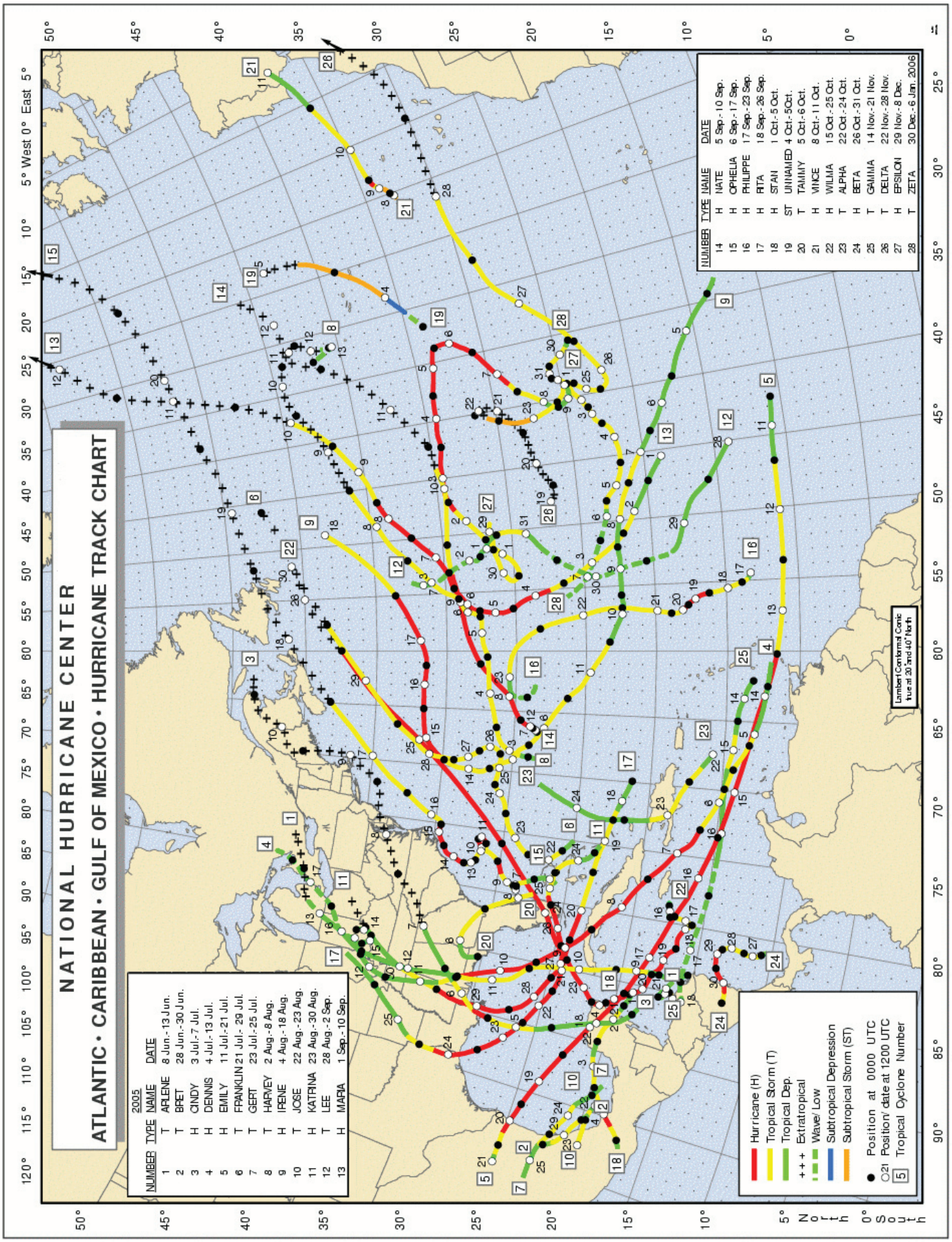
2005 Hurricane Season Summary Table

Name	Class	Dates (UTC)	Winds/Pressure mph/mb	Deaths	U.S. Damage (millions)
Arlene	TS	June 8-13	70/989	1	minor
Bret	TS	June 28-30	40/1002	1	
Cindy	H	July 3-7	75/991	1	320
Dennis	H	July 4-13	150/930	41	2230
Emily	H	July 11-21	160/929	6	minor
Franklin	TS	July 21-29	70/997		
Gert	TS	July 23-25	45/1005		
Harvey	TS	August 2-8	65/994		
Irene	H	August 4-18	105/970		
Jose	TS	August 22-23	60/998	6	
Katrina	H	August 23-30	175/902	>1300	>100000
Lee	TS	August 28 – September 2	40/1006		
Maria	H	September 1-10	115/962		
Nate	H	September 5-10	90/979		
Ophelia	H	September 6-17	85/976	1	70
Philippe	H	September 17-23	80/985		
Rita	H	September 18-26	180/895	7	10000
Stan	H	October 1-5	80/977	>1000	
Unnamed	ST	October 4-5	50/997		
Tammy	TS	October 5-6	50/1001		minor
Vince	H	October 8-11	75/988		
Wilma	H	October 15-25	185/882	22	12200
Alpha	TS	October 22-24	50/998	26	
Beta	H	October 26-31	115/962		
Gamma	TS	November 14-21	45/1002	37	
Delta	TS	November 22-28	70/980		
Epsilon	H	November 29 – December 8	85/981		
Zeta	TS	December 30 – January 6	65/994		

H = Hurricane, TS = Tropical Storm, ST = Subtropical Storm

References: National Hurricane Center, Tropical Meteorology Project (Colorado State University) and Wunderground.com

2005 Atlantic Basin Tropical Cyclone Track Map



Scenario For Disaster: A Category 4/5 Hurricane Striking The Upper Texas Coast

By Matthew Moreland and Brian Kyle

Introduction

Last year marked the costliest and one of the deadliest hurricane seasons on record for the United States. Over 1300 persons were killed and final damage estimates will likely exceed $125 billion. Once again, Harris County and the Houston/Galveston area were left almost untouched, narrowly escaping a direct hit from Hurricane Rita.

Since 1970, Harris County has more than doubled in population, welcoming more than two million new residents (see graphs, page 4). During this same period, income and property values have doubled per capita. Only one major hurricane has affected the Houston/Galveston region since 1970 and that was Hurricane Alicia in August 1983. Alicia produced significant damage, yet was rated a low-end Category 3 hurricane on the Saffir-Simpson Hurricane Scale as it made landfall (Category 2 as it moved into Harris County). Most of the new Houston area residents have never experienced an extreme or catastrophic hurricane. What can we expect if a Category 4 or 5 hurricane were to make landfall along the upper Texas coast? Can a Katrina-like event happen here?

Hurricane Rita, in September 2005, is an excellent case to study regarding all of the above questions. Rita passed south of Key West on Tuesday, September 20th and made landfall near the Texas/Louisiana border in the early morning hours of September 24th.

One of the most memorable issues regarding the impacts of Hurricane Rita on the upper coast was the prolonged evacuation traffic gridlock. Many of us have heard stories of, or personally experienced, a dreadful twelve to thirty hour trip to Dallas that on any other day would only take four to five hours. All major freeways leading out of Houston were a virtual parking lot. The extreme heat, car problems and lack of available fuel only added to the frustration. The traffic gridlock was caused by a number of factors. Most importantly, too many people evacuated and most decided to leave at the same time. Wall-to-wall media coverage of the devastation in Louisiana and Mississippi caused by Katrina had preceded the storm for three weeks which, without a doubt, rattled the nerves. Another player contributed to the domino effect: seeing many other people evacuate thereby making you feel the need to evacuate. Most individuals in southeast Texas had not previously developed a disaster plan prior to Hurricane Rita and believed the easiest and safest thing to do was to leave. A sizable majority of folks in the area have never experienced a major hurricane and a general fear of the unknown set in.

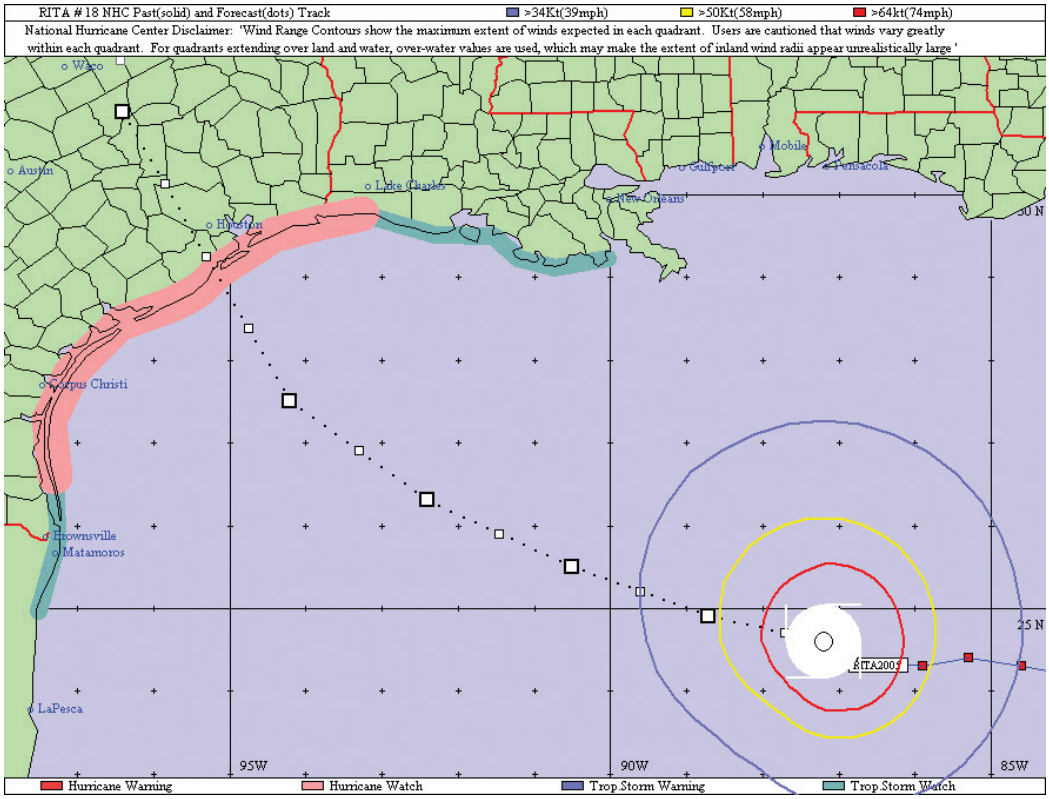


Figure 1: Forecast track of Hurricane Rita on Wednesday night, September 21, 2005. Source: HurrEvac.

Even more concerning is that most tropical cyclones that actually originate in the Gulf make landfall within 48 hours. Rita was actually a best case scenario regarding lead-time before landfall - over four days! Had Rita developed in the Gulf, decision making lead-time would have been significantly less than we had in September. If a similar scenario played out without the added time to prepare, and the hurricane subsequently hit the Houston/Galveston area, it would potentially have caused a significant loss of life with people stuck in their cars during the onset of hurricane conditions.

In hindsight, not everyone that evacuated needed to do so. This article will examine what conditions will be like if a Category 4 or 5 hurricane strikes the upper Texas coast and impacts the Houston/Galveston area. Our hopes are that with assistance from local emergency management officials and news media, information provided here will allow residents to make an informed decision on whether the best course of action is to evacuate or to shelter in place. Next time we may not be so lucky!

A Category 4 or 5 Hurricane Directly Impacting the Upper Texas Coast

Forecast Track

Figure 1 depicts the forecast track of Hurricane Rita on the Wednesday before landfall. Because of the large number of people who need to evacuate, decisions on evacuation needed to be made by this forecast. If this track had actually verified, it would be one of the worst case scenarios for the Houston/Galveston Bay area and Brazoria County.

What should one think when seeing this forecast track? First of all, it is important to remember that every forecast has some degree of uncertainty. In this example, expected landfall will not occur for another 60 hours. Forecast skill at 60 hours is such that landfall is just as likely to occur 135 miles either side of the line on this map as well as directly along the forecast track itself (see Table 1).

Given this forecast, everyone along the upper Texas and western Louisiana coasts from north of Corpus Christi to east of Lake Charles should prepare for a possible direct hit.

	Hours Before Landfall				
	24 hours	48 hours	72 hours	96 hours	120 hours
Forecast Error	70 miles	110 miles	160 miles	200 miles	280 miles

Table 1. Average Atlantic tropical cyclone track forecast error.

Storm Surge

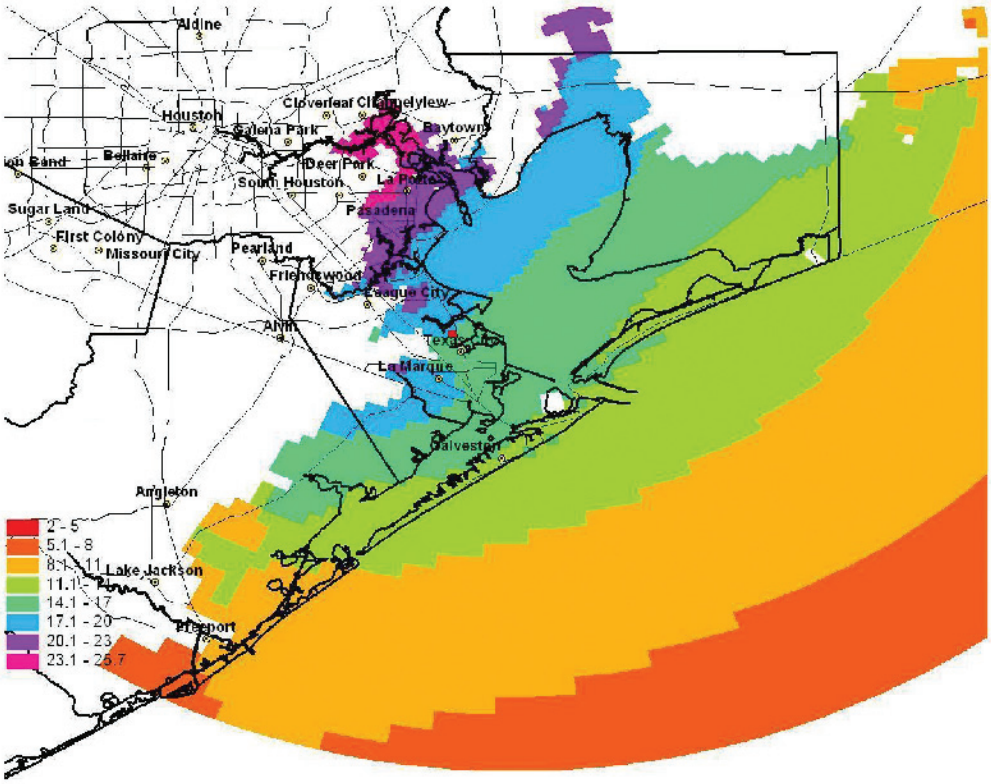


Figure 2: Forecast storm surge, in feet, if Hurricane Rita follows the September 21, 2005 forecast track (Figure 1) and makes landfall along the upper Texas coast near Freeport as a Category 4 hurricane. Source: SLOSH.

Storm surge, or a wall of water that is pushed toward the shore by the force of the winds swirling around the hurricane, can increase the mean water level 15 feet or more. Locations near and to the east (right) of landfall will experience the highest storm surge. The shaded areas in Figure 2 depict where storm surge flooding would occur.

With a large Category 4 or 5 hurricane making landfall near Freeport, storm surge would inundate all of Galveston Island and the Bolivar Peninsula and flood the communities on the western side of Galveston Bay including Texas City, Kemah, League City and Dickinson. In Chambers County, storm surge would flood stretches along Interstate 10 and most of the southern half of the county. In Brazoria County,

storm surge would flood Freeport and Surfside and could spread into parts of Lake Jackson and Angleton. Storm surge would spread into a large part of southeast Harris County, flooding La Porte and Baytown, and portions of Deer Park, Pasadena, Clear Lake and Webster. The Port of Houston would likely experience the highest storm surge of any location along the upper Texas coast during such a storm as strong onshore winds would funnel shallow water northwestward through the narrow part of Galveston Bay into the Ship Channel. The surge would result in billions of dollars in damage just in this area and would greatly cripple the oil and chemical industries. In a worst-case scenario, up to 600,000 homes and businesses could be flooded in Harris County alone, mainly in areas south and east of the Sam Houston Tollway, east of Interstate 45 and south of Interstate 10. This worst-case scenario would be comparable to the storm surge experienced in Mississippi from Hurricane Katrina.

Without hesitation, people living in areas subject to surge flooding should evacuate to higher ground - even if it is only a few miles away! Inland areas away from the immediate coast, the Houston Ship Channel and Galveston Bay will not be at risk from the storm surge. Prolonged widespread surge flooding as seen with Hurricane Katrina in New Orleans will not occur across the Houston metro area because Houston is situated above sea level, whereas many parts of New Orleans are below sea level. Historically, 90% of all hurricane deaths can be attributed to the storm surge. Increased public education regarding the necessity to evacuate the affected areas has caused a major decline in surge related deaths over the last couple of decades. However, storm surge deaths due to the devastation brought by Katrina should dispel any myths that we have solved the problem of large loss of life from hurricane surge in the United States.

Winds

Figure 3 depicts the expected peak wind gusts in each county had Rita taken this forecast track. Areas shaded in red would experience hurricane force winds (greater than 73 mph) and those in yellow would experience tropical storm force winds (39 to 73 mph).

Although hurricane force wind protection has been a requirement with home construction in southeast Texas since the late 1980s, many older and poorly constructed homes would have the potential to be severely damaged or completely destroyed.

Given this information, who should evacuate? If you are not in a mandatory evacuation area, it truly is a personal decision. How sturdy is your residence? Do you have an interior downstairs room away from windows that you can temporarily seek refuge in if it becomes necessary? Do you or your loved ones have medical issues that would be compromised if you lost power? Do you have enough supplies to live without electricity for at least three to seven days? It is important to remember that of all the hazards associated with hurricanes (winds, storm surge, rainfall, inland flooding and tornadoes), winds are the least likely element to cause death. Category 5 Hurricane Andrew, with winds measured in excess of 150 mph, destroyed or damaged nearly 100,000 homes in southern Dade County in Florida, yet resulted in a loss of life of less than fifty.

People that live in poorly constructed homes, mobile homes, and high rises should strongly consider evacuating or moving to a shelter. Recent studies indicate that the strongest winds in the eyewall are found near 1600 feet elevation where speeds can be as much as a full category stronger than winds observed at the surface.

Rainfall, Inland Flooding and Tornadoes

Inland flooding, rainfall and tornadoes can be the most difficult aspects of hurricanes to predict. Residents should not make their evacuation decisions based solely on these elements.

A good first guess into expected rainfall amounts is to divide the number 100 by the forward motion of the hurricane. If the hurricane is moving at 10 mph, expect 10 inches of rain (100 / 10 = 10 inches). A slower moving storm, say at 5 mph, could produce upwards of 20 inches of rain (100 / 5 = 20). Problems frequently arise where hurricanes speed up, or more importantly slow down, and estimates can be off by several factors!

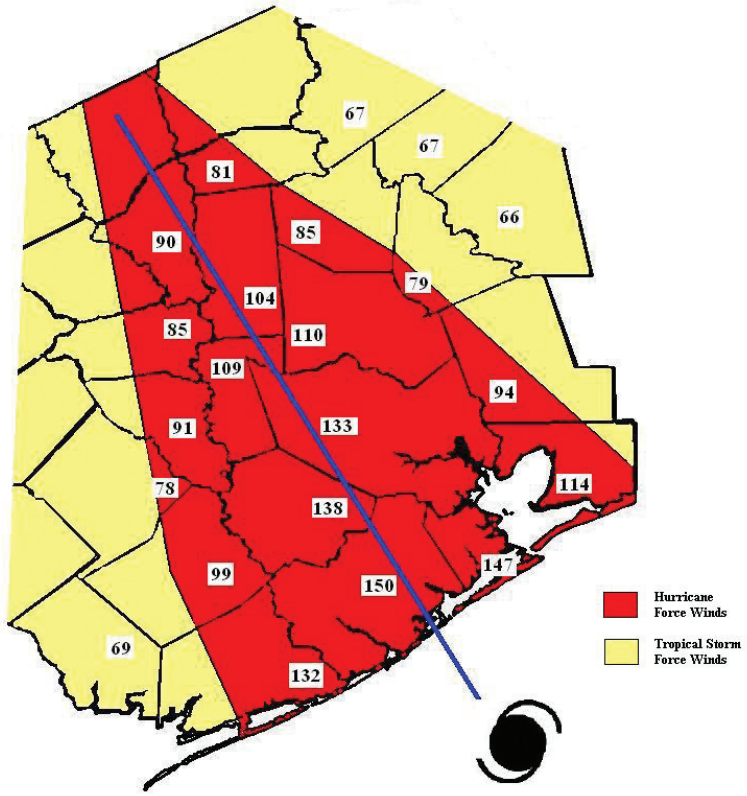


Figure 3: Forecast peak wind gusts by county, in mph, if Hurricane Rita follows the September 21, 2005 forecast track (Figure 1) and makes landfall along the upper Texas coast near Freeport as a Category 4 hurricane. Not everyone in the county would experience wind gusts this high – just locations closest to the eye of the hurricane. Source: HurrEvac.

Figure 4: Picture of flooding near downtown Houston associated with Tropical Storm Allison taken the morning of June 9, 2001. Source: Harris County Flood Control District.

Inland flooding has risen to the top of hurricane killers. Once moving inland, tropical cyclones can sometimes meander over the same geographic area for days at a time producing copious amounts of rain. In June 2001, Tropical Storm Allison made its way to the Lufkin area before drifting back over the Houston metro area. Allison produced upwards of 35 inches of rain across some areas. Widespread flooding caused $5 billion in damage and claimed 22 lives (Figure 4).

Unfortunately, these extreme events are difficult to pinpoint far enough in the future to ensure a safe and orderly early evacuation. They could just as easily occur 200 miles inland as they can near the coast. Again, decisions to mass-evacuate should not be made based on rainfall estimates. Instead, residents that live in low lying areas that typically flood during an afternoon thunderstorm, or those that live near creeks or rivers should consider going to a nearby shelter to ride out the storm. If caught in rising water, evacuate vertically. Move upstairs or on your roof if a dire situation calls for such an action. Remain sheltered in a safe place and do not go out "sight-seeing". In Tropical Storm Allison, no one drowned inside their home! All drowning deaths were in cars or people on foot.

Tornadoes are frequently associated with land-falling hurricanes. Though the numbers of tornadoes vary with each hurricane, the vast majority are located north and east of the hurricane's eye. Tornadoes cannot be predicted ahead of time and evacuation decisions should not be based on this element whatsoever!

Preparations

Whether or not you decide to evacuate, please refer to the section in the back of this booklet labeled "Your Family Hurricane Plan Checklist" for detailed information on what to do to prepare for the threat of a Category 4 or 5 hurricane.

The Aftermath

A recent engineering study conducted by Dodson & Associates in association with the Harris County Office of Homeland Security and Emergency Management determined that a strong Category 4 or 5 hurricane directly striking the Houston/Galveston area would cause over $40 billion in damage in Harris County alone. The Texas Governor's Division of Emergency Management has stated that a Category 4 hurricane making a direct strike on the upper Texas coast would cause $70 to $75 billion in damage to a 31 county area of southeast Texas (Figure 5), destroy around 120,000 residences, and generate 124 million tons of debris.

A joint study was conducted in 1999 between the Harris County Office of Emergency Management, the Harris County Flood Control District, the National Weather Service, the Harris County Judges Office, Dodson & Associates, Inc., and EQE International, Inc. to determine what would result in the aftermath of a hurricane like Katrina or Rita.

Critical facilities like communication and health care could be interrupted or in some cases unavailable for days or weeks. The Medical Center could be severely crippled by flooding, damage, or a lack of power, and possibly even shut down for a long period of time. Critical services like fire, ambulance, and law enforcement will be overloaded for some time after the storm leaves. Power outages will be widespread (likely affecting millions), and the power could be out for days, if not weeks. Bridge, dam and roadway failures are possible. Both major airports would be closed for an extended period.

The hurricane could result in health-related hazards such as the release of toxic substances (from flooding and debris), a prolonged shortage of water and wastewater services (from damage, flooding, and a lack of electrical service), and a shortage of garbage and debris collection and disposal services.

Long-term effects from the hurricane could include the need for massive infrastructure repairs, and the relocation of population from heavily damaged parts of the city to less damaged areas. Business failures, especially to small businesses, could be widespread, resulting in a loss of the area's economic base. Property values could drop on all forms of property for a period of time following the hurricane.

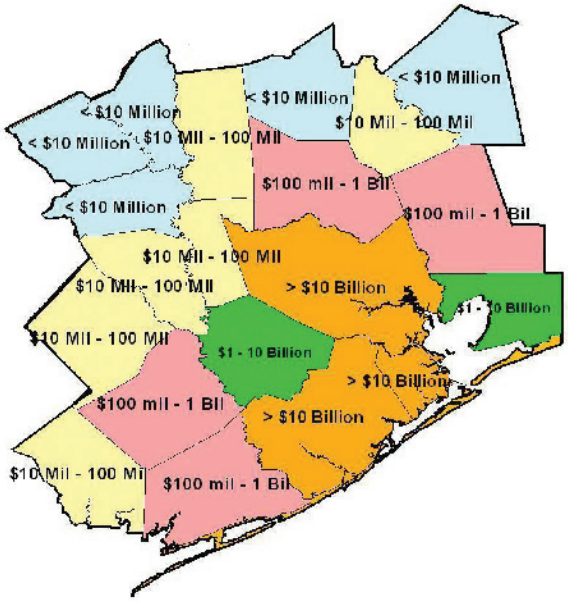


Figure 5: Estimated damage that would result from a direct strike by a Category 4 hurricane on the upper Texas coast (listed by county). Source: Texas Governor's Division of Emergency Management (2005).

While the upper Texas coast has seen a reprieve from hurricanes in recent years, there was a time when hurricane activity was much more active here. Although the Texas coast has been spared from any Category 5 hurricanes, in the early part of the 20th century, the Houston area was directly hit by two Category 4 hurricanes 15 years apart – in 1900 and 1915. Each of these storms would have produced well over $30 billion in damage if they had struck today. The last Category 4 hurricane to strike the Texas coast was Carla in 1961 – well before the economic and population boom we have seen in recent decades. To say that we are overdue is an understatement.

Summary

Hopefully, information included in this article will be helpful when preparing your hurricane plan – and you need one! Residents in mandatory evacuation zones need to follow the advice of local officials when they order an evacuation (see pages 24 - 29 for evacuation zone maps). Most importantly, you need to take the initiative to do what is best for you and your loved ones. If your residence is in the storm surge zone, you should evacuate. If your home is at risk from rainfall or river flooding, you might consider evacuating to a higher elevation or to a nearby shelter. Your home, if well constructed and properly prepared for high winds, could be the best and safest option you have if winds are the primary hazard at your location. If, however, you live in a poorly constructed home or apartment, or live in a high rise, you should consider evacuating to a safer refuge. Just remember, winds are the least likely element of a hurricane to cause fatalities. The last place you want to be is stuck outside in your car when the big one makes landfall. Make use of the information in this booklet. Share it with your friends and neighbors so they too can develop a hurricane plan in advance.

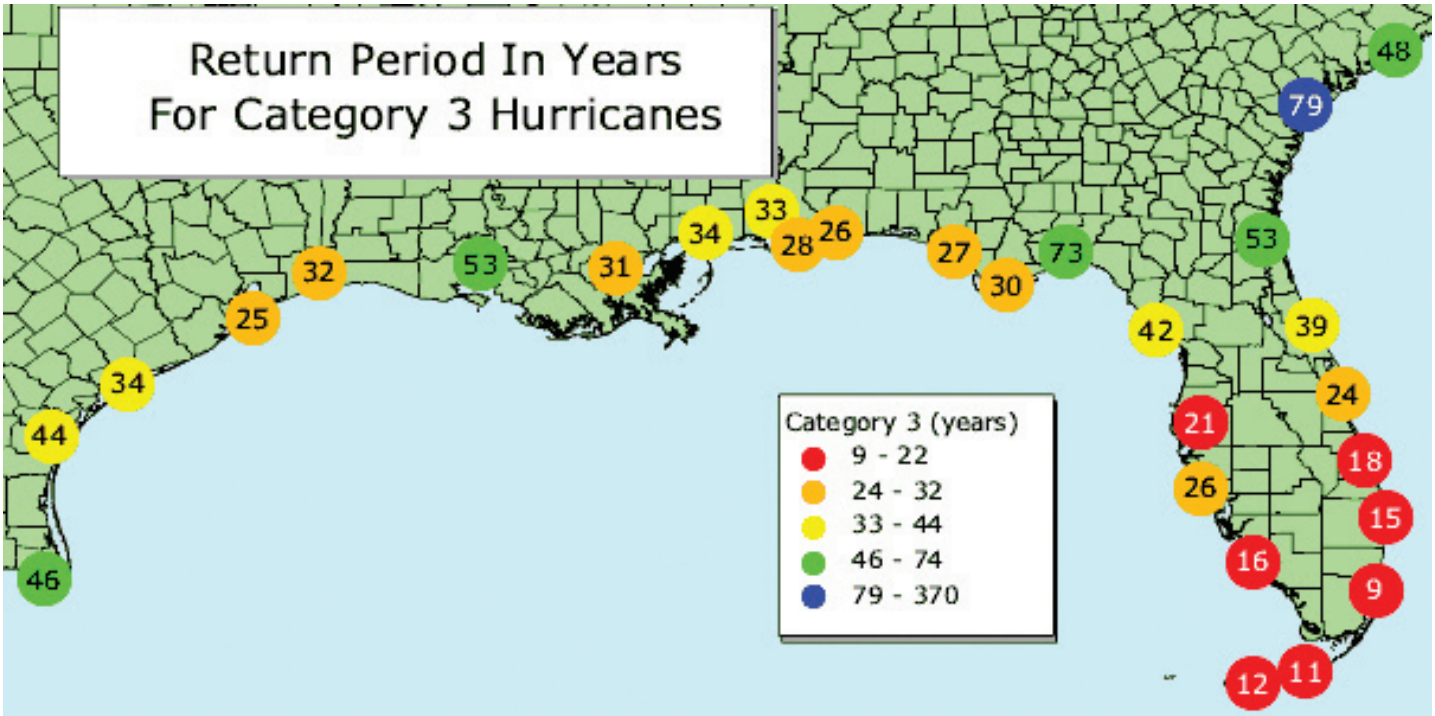
References:

- "Models Show 'Massive Devastation' In Houston" Eric Berger **Houston Chronicle** Feb. 20, 2005
- Texas Governor's Division of Emergency Management hurricane report (early 2005)
- "Hurricane Mitch Scenario" (Joint Study) (www.hcoem.org/videos.htm) Harris County Office of Homeland Security and Emergency Management 1999

Footnote:

Similar graphics and scenarios in this article are also available for Category 4 or 5 hurricanes making landfall in the Matagorda Bay area. Contact the Houston/Galveston National Weather Service by phone or e-mail and we will be happy to provide you with that information.

Upper Texas Coast Tropical Cyclone Climatology



This graphic represents the average return period in years for a major hurricane (Category 3 or higher) for various sections of the U.S. coastline. For the Houston/Galveston area and the upper Texas coast, the average return period is 25 years, meaning a major hurricane can be expected to strike this area every 25 years. The last major hurricane to strike this area was Hurricane Alicia in 1983 – 23 years ago. The map clearly indicates that south Florida and the Florida Keys have the highest frequency of major hurricanes, averaging a major hurricane every 9 to 15 years.

Saffir-Simpson Hurricane Scale

All hurricanes are dangerous, but some are more so than others. The way storm surge, wind, and other factors combine determines the hurricane's destructive power. To make comparisons easier, and to make the predicted hazards of approaching hurricanes more clear to emergency officials, hurricane forecasters use a disaster-potential scale, which assigns storms to five categories. Category 1 is a minimum hurricane; Category 5 is the worst case scenario. The criteria for each category is shown below. The winds are used in the determination of each category.

Category	Central Pressure (mb)	Winds (mph)	Upper Texas Coast Surge (Feet)		Damage	Storm Example
			Coast	Bays		Name/Year
1	980+	74-95	4-5	4-7	**Minimal:** No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery and trees.	Claudette (TX) 2003
2	965-979	96-110	6-8	8-12	**Moderate:** Some roofing material, door and window damage to buildings. Considerable damage to vegetation, mobile homes and piers.	Frances (FL) 2004
3	945-964	111-130	9-12	13-18	**Extensive:** Structural damage to small residences and utility buildings with minor curtainwall failures. Mobile homes destroyed.	Alicia (TX) 1983
4	920-944	131-155	13-18	19-24	**Extreme:** More extensive curtainwall failures with some complete roof structure failure on small residences. Major beach erosion.	Carla (TX) 1961
5	<920	>155	18+	24 +	**Catastrophic:** Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away.	Andrew (FL) 1992

American Red Cross

ATLANTIC HURRICANE TRACKING CHART

Always remember

If you live along the coast or in a low-lying area, if you live in a mobile home in an area subject to hurricane water or wind, or if authorities tell you to... Go!

Storm Surge

A storm surge is a dome of water often 50 miles wide that comes sweeping across the coastline near the area where the eye of the hurricane makes landfall. The surge, aided by the hammering effect of breaking waves, acts like a giant bulldozer sweeping away everything in its path. Nine out of ten hurricane deaths are caused by storm surge. That's why it's important to leave well before a hurricane may come your way.

Wind Damage

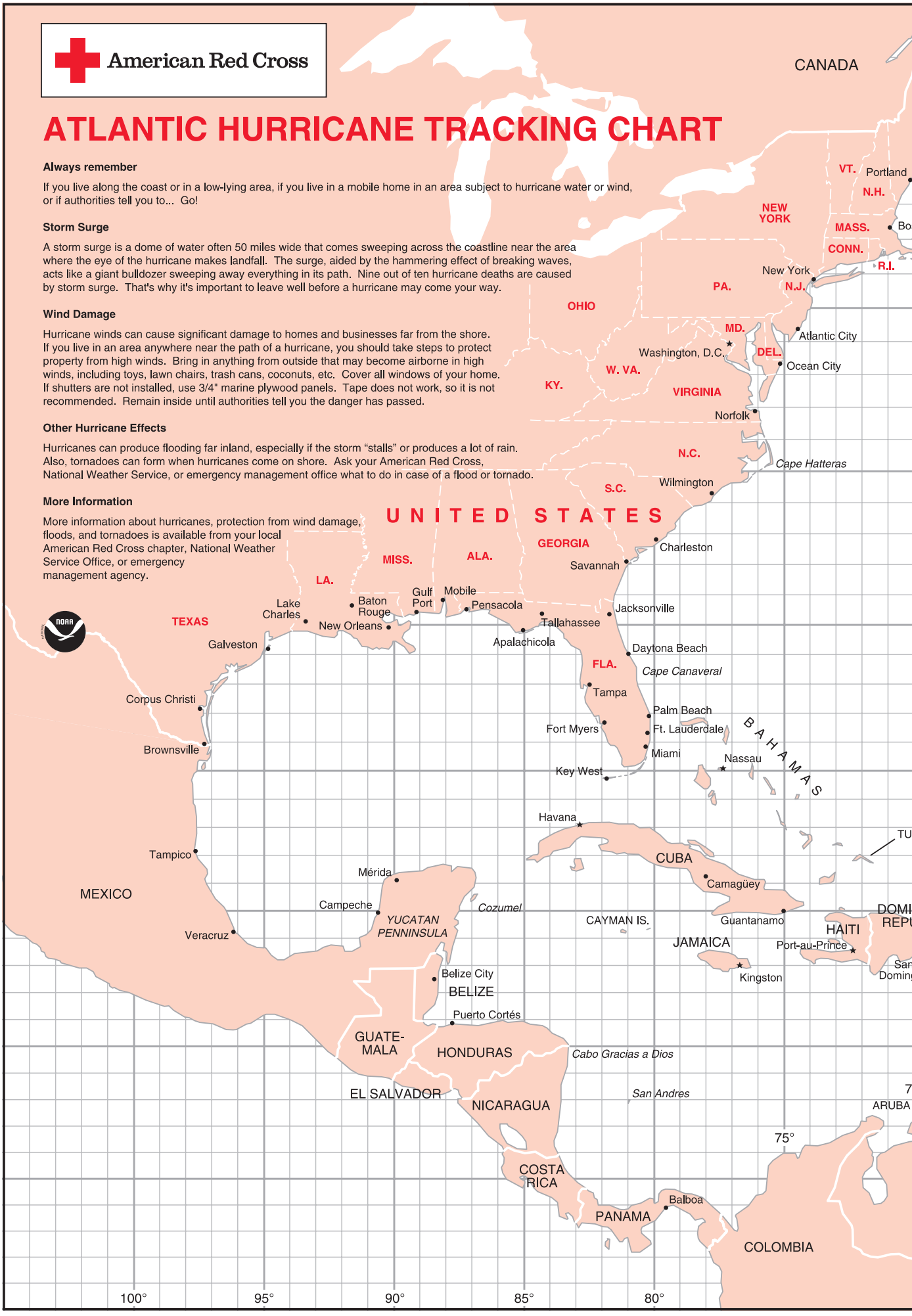
Hurricane winds can cause significant damage to homes and businesses far from the shore. If you live in an area anywhere near the path of a hurricane, you should take steps to protect property from high winds. Bring in anything from outside that may become airborne in high winds, including toys, lawn chairs, trash cans, coconuts, etc. Cover all windows of your home. If shutters are not installed, use 3/4" marine plywood panels. Tape does not work, so it is not recommended. Remain inside until authorities tell you the danger has passed.

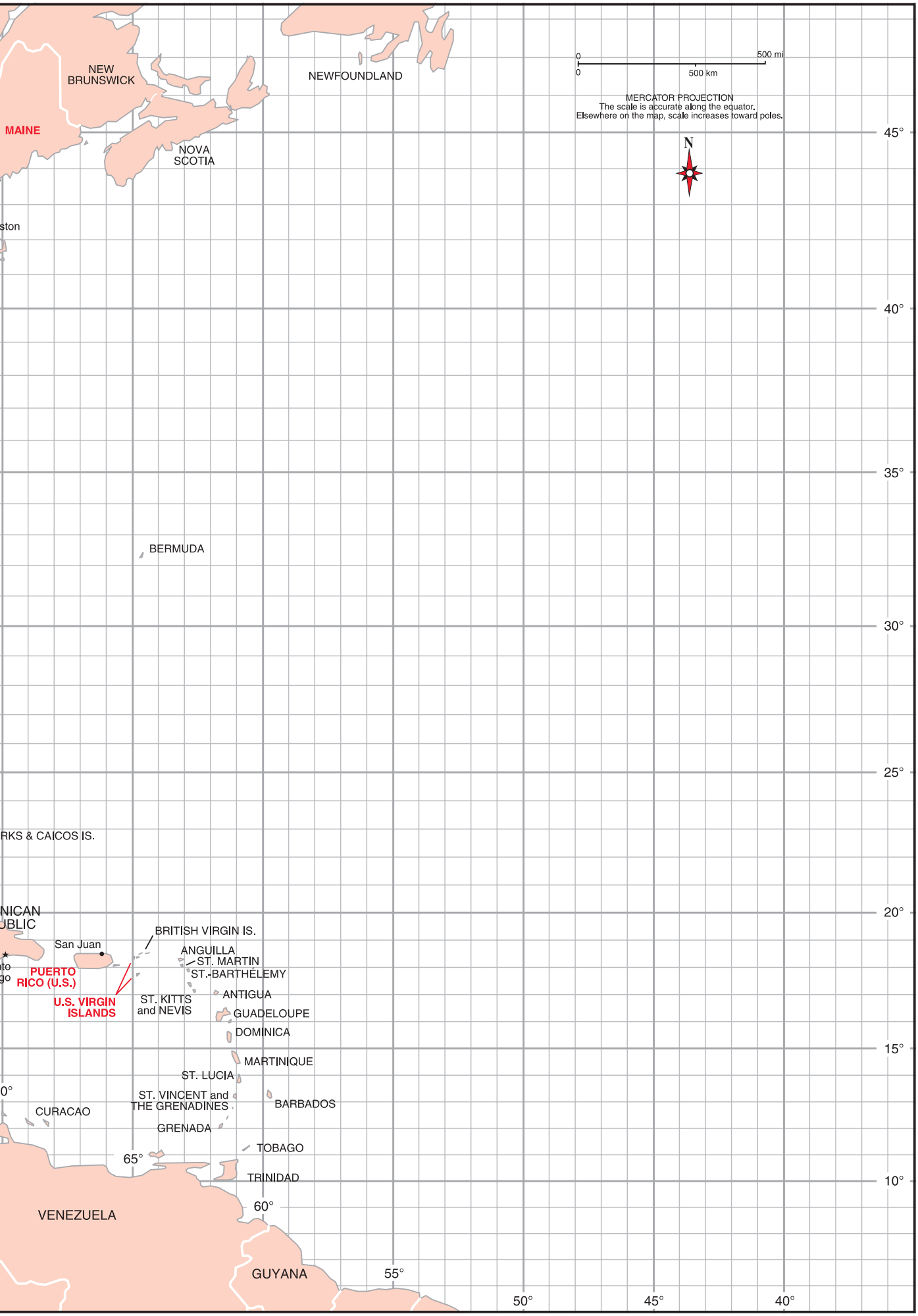
Other Hurricane Effects

Hurricanes can produce flooding far inland, especially if the storm "stalls" or produces a lot of rain. Also, tornadoes can form when hurricanes come on shore. Ask your American Red Cross, National Weather Service, or emergency management office what to do in case of a flood or tornado.

More Information

More information about hurricanes, protection from wind damage, floods, and tornadoes is available from your local American Red Cross chapter, National Weather Service Office, or emergency management agency.





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Feb. 1995

Naming of Hurricanes

The Tropical Prediction Center near Miami, FL keeps a constant watch on oceanic storm-breeding areas for tropical disturbances which may herald the formation of a hurricane. If a disturbance intensifies into a tropical storm (rotary circulation and wind speeds above 38 miles per hour), the Center will give the storm a name. A separate name set is used each year beginning with the first name of the set. The letters Q, U, X, Y and Z are not included because of scarcity of names beginning with those letters.

The name lists have an international flavor because tropical storms and hurricanes affect other nations and are tracked by the public and weather services of countries other than the United States. Names for these lists are agreed upon by nations involved during international meetings of the World Meteorological Organization.

For several hundred years, many hurricanes in the West Indies were named after the particular saint's day on which the hurricane occurred. Ivan R. Tannehill describes in his book "HURRICANES" the major tropical storms of recorded history and mentions many hurricanes named after saints. For example, there was "Hurricane Santa Ana" which struck Puerto Rico with exceptional violence on July 26, 1825, and "San Felipe" (the first) and "San Felipe" (the second) which hit Puerto Rico on September 13th in both 1876 and 1928.

Tannehill also tells of Clement Wragge, an Australian meteorologist, who began giving women's names to tropical storms before the end of the 19th Century.

An early example of the use of a woman's name for a storm was in the novel "STORM" by George R. Stewart, published by Random House in 1941 and since filmed by Walt Disney. During World War II, this practice became widespread in weather map discussions among forecasters, especially Air Force and Navy meteorologists who plotted the movement of storms over the wide expanses of the Pacific Ocean.

In 1953, the United States abandoned as confusing a three-year old plan to name storms by phonetic alphabet (Able, Baker, Charlie) when a new, international phonetic alphabet was introduced. That year, this nation's weather service began using female names for storms.

The practice of naming hurricanes solely after women came to an end in 1978 when men's and women's names were included in eastern North Pacific storm lists. In 1979, male and female names were included in lists for the Atlantic, Caribbean, and Gulf of Mexico.

Experience shows that the use of short, distinctive names in written, as well as in spoken communications, is quicker and less subject to error than the older more cumbersome latitude-longitude identification methods. These advantages are especially important in exchanging detailed storm information between hundreds of widely scattered stations, airports, coastal bases and ships at sea.

The use of easily remembered names greatly reduces confusion when two or more tropical cyclones occur at the same time. For example, one hurricane can be moving slowly westward in the Gulf of Mexico, while at exactly the same time another hurricane can be moving rapidly northward along the Atlantic coast. In the past, confusion and false rumors have arisen when storm advisories broadcast from one radio station were mistaken for warnings concerning an entirely different storm located hundreds of miles away.

These lists are recycled every 6 years (the 2006 list will be reused in 2012). Several names have been changed since the lists were last used. For the 2006 season, Kirk replaces Keith which was retired after the 2000 season. For the 2007 season, Andrea, Ingrid and Melissa replace Allison, Iris and Michelle which were retired after the 2001 season.

Names of Atlantic Storms Through 2010

2006	2007	2008	2009	2010
Alberto	Andrea	Arthur	Ana	Alex
Beryl	Barry	Bertha	Bill	Bonnie
Chris	Chantal	Cristobal	Claudette	Colin
Debby	Dean	Dolly	Danny	Danielle
Ernesto	Erin	Edouard	Erika	Earl
Florence	Felix	Fay	Fred	Fiona
Gordon	Gabrielle	Gustav	Grace	Gaston
Helene	Humberto	Hanna	Henri	Hermine
Isaac	Ingrid	Ike	Ida	Igor
Joyce	Jerry	Josephine	Joaquin	Julia
Kirk	Karen	Kyle	Kate	Karl
Leslie	Lorenzo	Laura	Larry	Lisa
Michael	Melissa	Marco	Mindy	Matthew
Nadine	Noel	Nana	Nicholas	Nicole
Oscar	Olga	Omar	Odette	Otto
Patty	Pablo	Paloma	Peter	Paula
Rafael	Rebekah	Rene	Rose	Richard
Sandy	Sebastien	Sally	Sam	Shary
Tony	Tanya	Teddy	Teresa	Tomas
Valerie	Van	Vicky	Victor	Virginie
William	Wendy	Wilfred	Wanda	Walter

Evacuation 2006: Will It Be Better?

By Gene Hafele

No one needs to be reminded about the evacuation that took place as Hurricane Rita approached the upper Texas coast. A couple of items that highlighted the evacuation prior to Rita included: it took too long, too many people died and many ran out of gas. Many people that evacuated last year are saying, "...never again. I would rather take my chances at home than be on the highway for 12 to 24 hours or more." If people ignore the evacuation orders because of their memories of Rita, hundreds, maybe thousands of lives could be lost due to the storm surge and high winds. It is important that the citizens of southeast Texas are informed of the improvements to the evacuation plan that will be implemented in 2006 in the event another major hurricane threatens our area.

In 2005, contra-flow on the major highways leaving Houston was established on the fly. No plan existed prior to Rita to establish contra-flow on any of the evacuation routes leaving Houston. In 2006, in the event of an evacuation, there will be plans in place to establish contra-flow on I-45 north, I-10 west and on Highway 290 heading northwest if needed. This will help alleviate the bottlenecks that exist on these evacuation routes and keep the traffic moving.

Hurricane Rita evacuation on I-45 North (Thursday, September 22, 2005)
Source: Texas Department of Transportation.

During Rita, many gas stations ran out of gas because they had an inadequate supply on hand while other gas stations closed and their employees evacuated with everyone else. With the new plan, gasoline stations will have their tanks filled prior to when the evacuation orders are given. Additional supplies will be made available during the evacuation in case the need arises. Gas station owners will be encouraged to stay open to help with the needs of the evacuees.

During last year's Rita evacuation, motorists faced long delays in record heat. The lack of food and water along the evacuation routes coupled with the heat produced life-threatening conditions, especially for the elderly. In 2006, rest areas will be established at certain intervals along the major evacuation routes to offer some basic necessities such as water, snacks and medical needs.

One of the most important items that will take place prior to the upcoming hurricane season is the continued education of the citizens in southeast Texas. At the National Hurricane Center, one of their favorite sayings concerning evacuation is "Run from the Water and Hide from the Wind." The primary portion of the population that needs to evacuate inland are the areas that will be affected by the storm surge. In Harris, Galveston and Brazoria Counties, some estimates say nearly 1.2 million people live in this area. In Rita, an estimated three million people tried to leave the area, and this "over-evacuation" was the primary contribution to the traffic nightmare and highway congestion. For areas inland from surge zones, people in reasonably good health, who do not live in mobile homes, are advised to stay home and prepare for the wind and subsequent loss of power. By doing so, evacuation of folks from the surge zone will occur more efficiently with reduced risk to the lives of everyone.

Bottom Line: During the 2006 Hurricane Season, please follow the advice of your local officials.

Tidal Flooding Along the Upper Texas Coast

Introduction

Because of our very low elevation above sea level on the upper Texas coast, tidal flooding remains a significant hazard to waterfront communities. For tropical systems, ranging from tropical depressions to hurricanes, storm surge is the dominant factor. Storm surge is a large dome of water often 50 to 100 miles wide that sweeps across the coastline near and to the right of where the system makes landfall. The stronger the system, the slower its forward motion, and the shallower the offshore water, the higher and more prolonged the surge will be.

However, even if the tropical system is not forecast to make landfall along the Texas coastline, it is important to continually monitor its size, position and strength. This is because abnormally high water levels along the Texas coast are highly dependent on meteorological conditions, more-so than the astronomical conditions used to produce tide charts. In addition to storm surge itself, various factors lead to above normal tides including wind direction, wind speed, fetch and duration. These factors are described below.

Wind Direction

The initial transport of water near the surface is 45 degrees to the right of the wind direction. So, an east wind will actually transport more water in a northerly direction (toward Galveston) than a south wind which would "push" water more to the east of the region. Wind directions that are favorable for elevated water levels, assuming other variables that are also met, include NE, ENE, E, ESE, SE. An easy way to figure out which way the "push" of water is headed is to turn your back to the wind, then point 45 degrees to the right.

Wind Speed

Stronger wind speeds (out of the NE, ENE, E, ESE, or SE) correspond to a "stronger" push. In addition, there will be higher waves on top of the elevated water level. Higher winds speeds essentially "trap" water up along the upper Texas coast and bays as conditions are not conducive for the water to recede back into the Gulf.

Fetch and Duration

The fetch is the geographic distance that the wind travels. Duration corresponds to the amount of time a significant sustained wind prevails along the fetch. Both are important factors determining just how much water will "pile up" along the coast. For instance, a fetch of 25 mph easterly winds extending all the way to the west coast of Florida and maintaining itself for three days will transport more water toward Texas than, say, a fetch extending from just off the Louisiana coast that has only been prevailing for 24 hours.

Putting It All Together

When the conditions described above all come together, water levels along the Texas coast will rise above astronomical levels that one would see in area tide tables. The lowest lying elevations and roads, especially Galveston Bay locations, appear to begin flooding when *observed* tides reach around four feet. Structural damage to roads and personal property often results, but by far the most significant impact is usually the resulting beach erosion. Several million dollars worth of erosion has been estimated by such events in just the past five to eight years. In addition, many "front row" beach homes have been lost and/or involved in litigation due to the vegetation line being pushed back to behind their property. According to the Texas Open Beaches Act, the public beach is defined seaward of the vegetation line. Previous effects that tides have had on various communities are listed on the next page. Elevated water levels will continue until one of two things happen: the wind direction turns to more of a southerly, westerly or northerly direction, or wind speeds decrease.

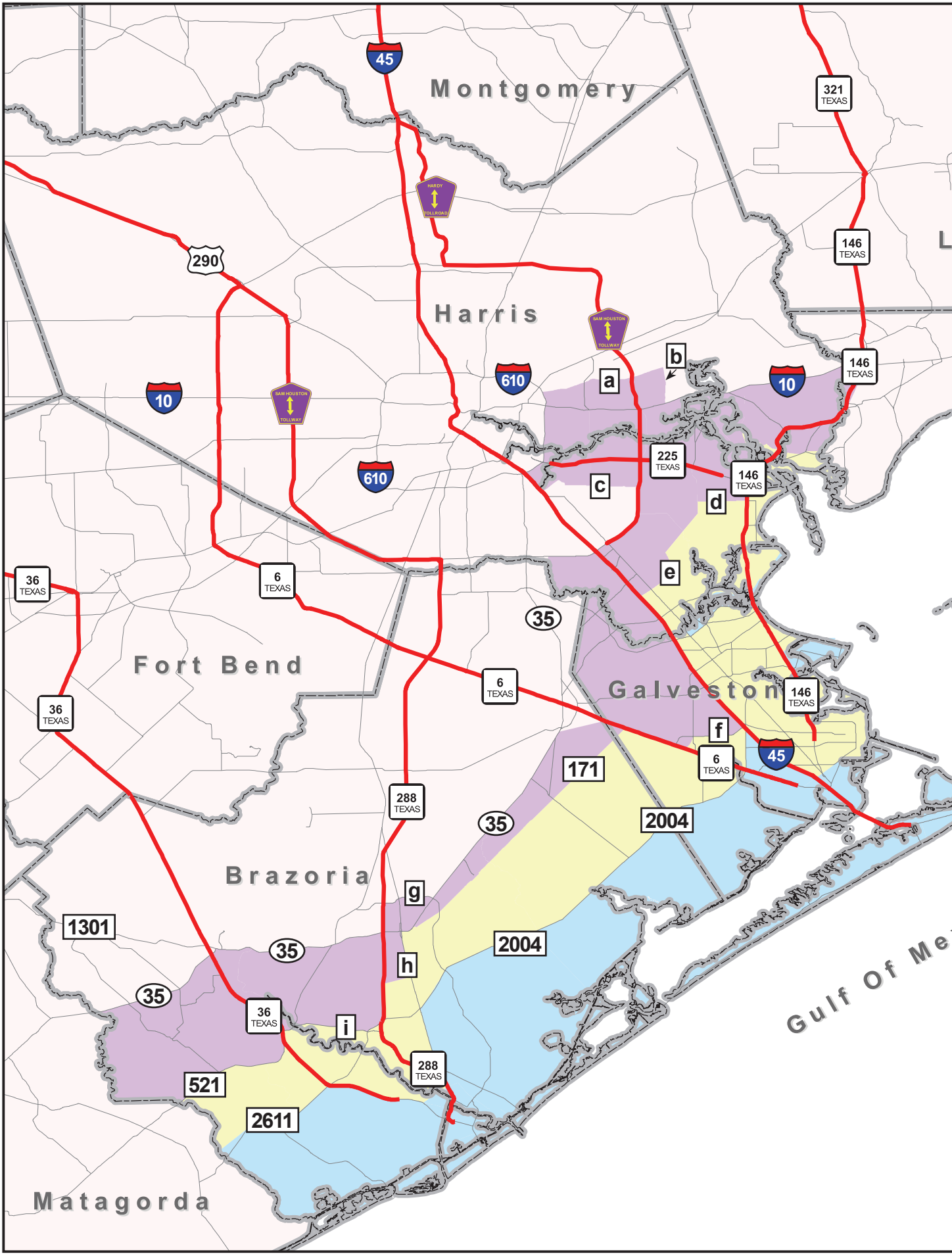
Where to Obtain Tide Levels

The Houston/Galveston NWS produces a daily tide forecast that is sent to the media and internet. The forecast is also put on NOAA Weather Radio each day. We particularly like the PORTS data, which shows real-time water levels at various locations versus the predicted astronomical level (tide table). You can find the link to the tide forecast and PORTS data off of our website at: www.srh.noaa.gov/hgx/marine.htm

Tidal Flooding Along the Upper Texas Coast

Critical Water Levels Along the Upper Texas Coast

	4.0 feet	4.5 feet	5.0 feet	5.5 feet	6.0 feet	6.5 feet
Galveston Bolivar Peninsula	Lowest streets begin to flood especially on the west end of Galveston. Portions of HWY 6 between I-45 and Hitchcock begin to flood.	Parts of HWY 87 become impassable.	Ferry service to and from Bolivar ceases. Many feeder roads near the bay begin to flood.			
Kemah Seabrook Clear Lake Texas City	Toddville Rd begins to flood. Lower portions of Red Bluff Rd between Bay Area Blvd & HWY 146 begin to flood.	Parts of Toddville Rd closed.	Water 3 feet deep and in homes along Toddville Rd.			
Chambers County	West Bayshore Rd. between Anahuac and Oak Island begins to flood. HWY 124 between High Island and FM 1985 begins to flood.	FM 562 northeast of Smith Point begins to flood.				FM 1985 between FM 562 and HWY 124 begins to flood.
Surfside			Water approaches dunes. Portions of FM 523 between HWY 332 & FM 2004 begin to flood. FM 2918 near the mouth of the San Bernard River begins to flood.	Streets near the beach begin to flood. Lowest lying portions of HWY 288 near Freeport begin to flood.	San Luis Pass Bridge may close depending on HWY 257 road conditions in Brazoria County.	
Jamaica Beach (bayside)	Lowest streets begin to flood.	Flooding moves further inland.		Half the village becomes inundated.		3-4 feet of water on streets and in homes.
Matagorda Area				Water on FM 2031.	Bridge is closed.	
Sargent Area					Bridge is closed.	


Montgomery
Harris
Fort Bend
Galveston
Brazoria
Matagorda
Gulf Of Me
45
290
10
610
321 TEXAS
146 TEXAS
225 TEXAS
6 TEXAS
36 TEXAS
288 TEXAS
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a
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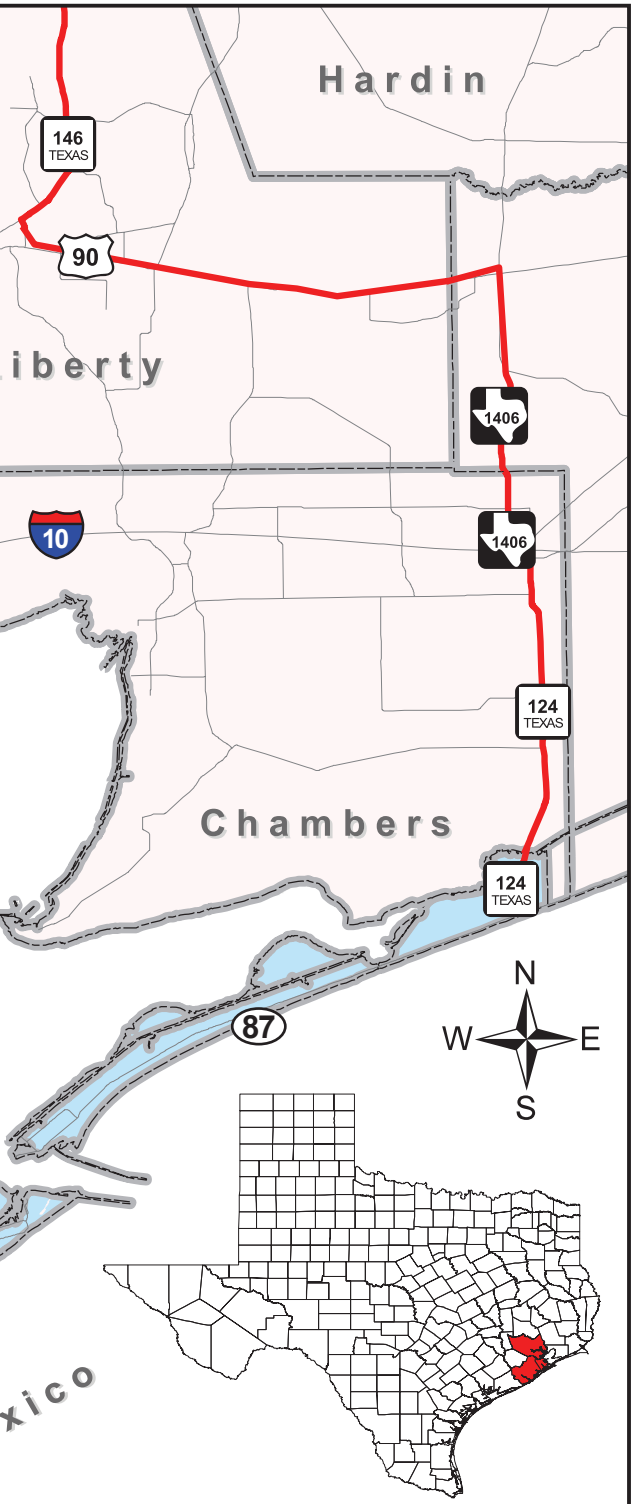


a - Wallisville Road
b - Sheldon Road
c - Pasadena Blvd
d - Fairmont Pkwy
e - El Dorado Blvd
f - FM 646
g - Hwy 35 Bypass
h - Hwy 288B
i - Hwy 332

Brazoria/Galveston/Harris County

Evacuation Zones

	Zone A	Category 1-2 Hurricane
	Zone B	Category 3 Hurricane
	Zone C	Category 4-5 Hurricane

Evacuation Routes

SIGN

Saffir Simpson Scale

Hurricane Category	Windspeed (MPH)
1	74-95
2	96-110
3	111-130
4	131-155
5	>155

Hurricane Evacuation Information

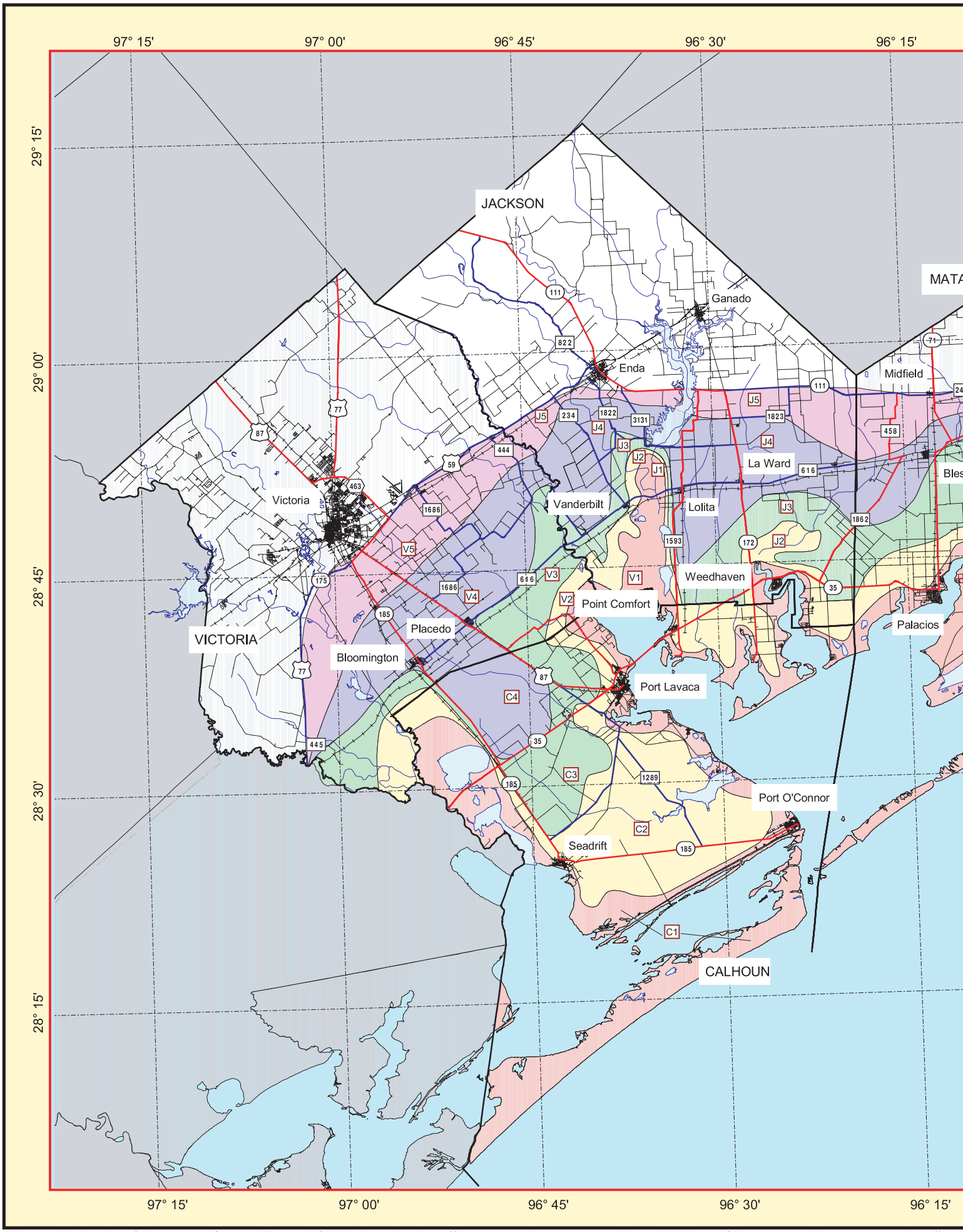
Find the location of your home on the map and note the evacuation zone where it is located. If you are in the **BLUE ZONE (A)**, plan to evacuate for all hurricanes. Those in the **YELLOW ZONE (B)** should plan to evacuate for Category 3, 4 or 5 storms. If you live in the **PURPLE ZONE (C)**, you should plan to evacuate for a Category 4 or 5 hurricane.

If you live near an evacuation zone boundary and are unsure of the evacuation zone you are in, error on the side of caution and assume you are in the zone nearest the coast. If you live in a mobile home in any of the three evacuation zones, plan to evacuate any time a hurricane threatens.

The main evacuation routes are highlighted in red on the map. These routes will take you out of the area of immediate danger to safety and shelter further inland. When a hurricane threatens, listen for instructions from local officals on how and when to evacuate and follow those instructions.

FEMA

US Army Corps of Engineers



Hazard Reduction & Recovery Center, Texas A&M University, http://hrrc.tamu.edu *Texas Division of Emergency Management, http://www*

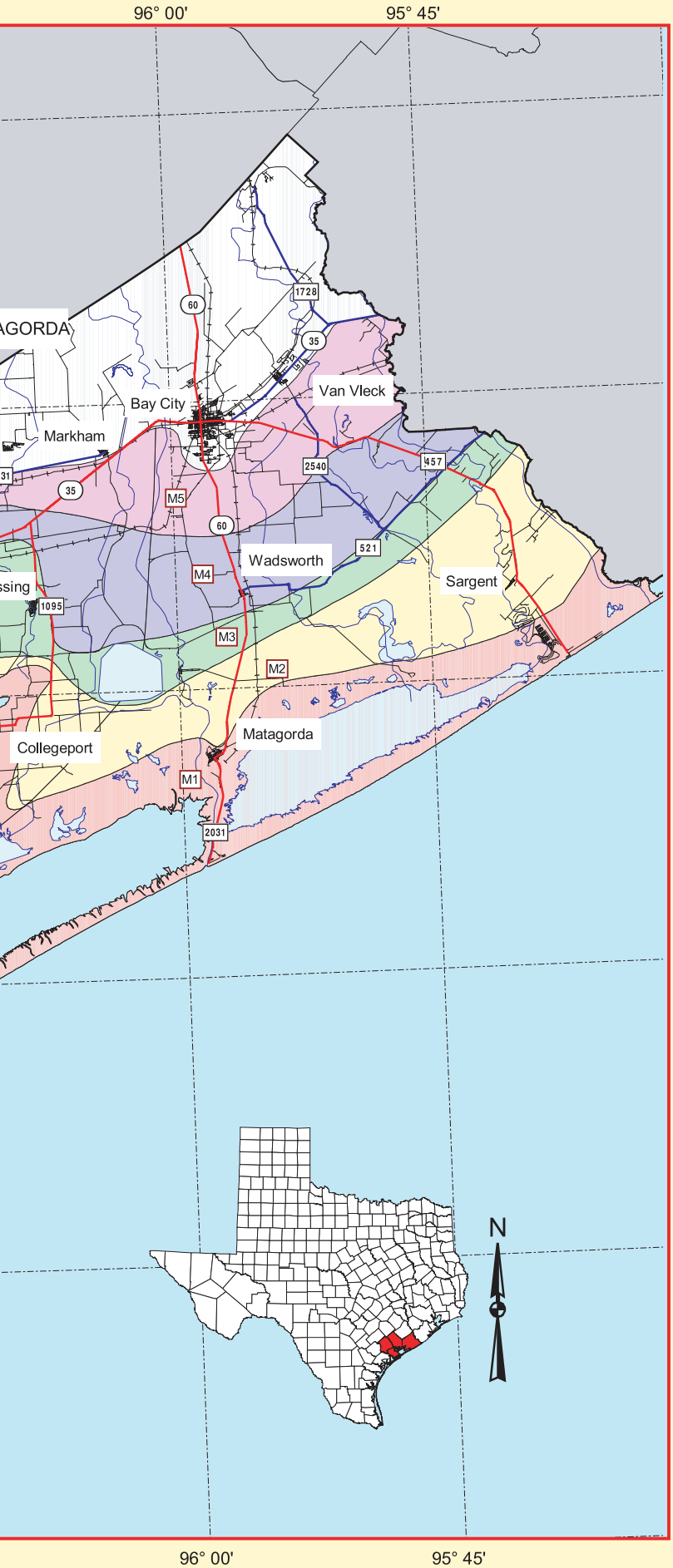
Matagorda Study Area

8 0 8 16 Miles

Saffir-Simpson Scale	
Hurricane Category	Windspeed (MPH)
1	74-95
2	96-110
3	111-130
4	131-155
5	>155

Legend
- Primary Evacuation Route
- Secondary Evacuation Route
- County Boundary
- Risk Area 1
- Risk Area 2
- Risk Area 3
- Risk Area 4
- Risk Area 5

Risk Area numbers correspond to hurricane categories. For example, in the event of a Category 3 hurricane, Risk Areas 1, 2, 3 would be threatened.



What To Do When A Hurricane Threatens

Find the location of your home on the map and note the risk area where it is located. Plan to evacuate for any hurricane whose category is equal to or greater than the number of your risk area. Thus, those in Risk Area 5 need to evacuate only from a Category 5 hurricane, but those in Risk Area 1 should evacuate from all hurricanes.

If you live near a risk area boundary and are unsure of which risk area you are in, err on the side of caution. Assume that you are in the risk area that will be affected by a lower hurricane category (i.e., a risk area that has a smaller number and is nearer the coast). If you live in a mobile home in any of the five risk areas, plan to evacuate any time a hurricane threatens.

During a hurricane watch, listen to your radio or television constantly. The Emergency Alert stations for your area are KTRH 740 AM and KPRC 950 AM (Matagorda Co.), and KVIC 95.1 FM and KRNX 1340 AM (all other counties). The NOAA Weather Radio Stations are 162.475 megahertz (Port O'Conner), 162.400 (Victoria) and 162.425 (Bay City).

Begin evacuation preparations during the hurricane watch so you will be ready to leave when you receive a hurricane warning. If you will be traveling with young children, older family members, or people with special needs, consider leaving before you receive an official evacuation warning.

When local officials tell you to evacuate, do so immediately. Plan to take the nearest evacuation route (marked by a red line on the map), but be prepared to take an alternate route if your primary evacuation route is congested. Be sure to take plenty of bottled water and snacks with you because the trip may take longer than usual due to congested roads.

Identify a place to stay before you leave. If you plan to stay in a hotel or motel, call ahead to make reservations. If you need to stay in a public shelter, public officials in host cities will let you know where one is located when you arrive. Many hotels and most public shelters do not take pets, so make other arrangements if necessary.

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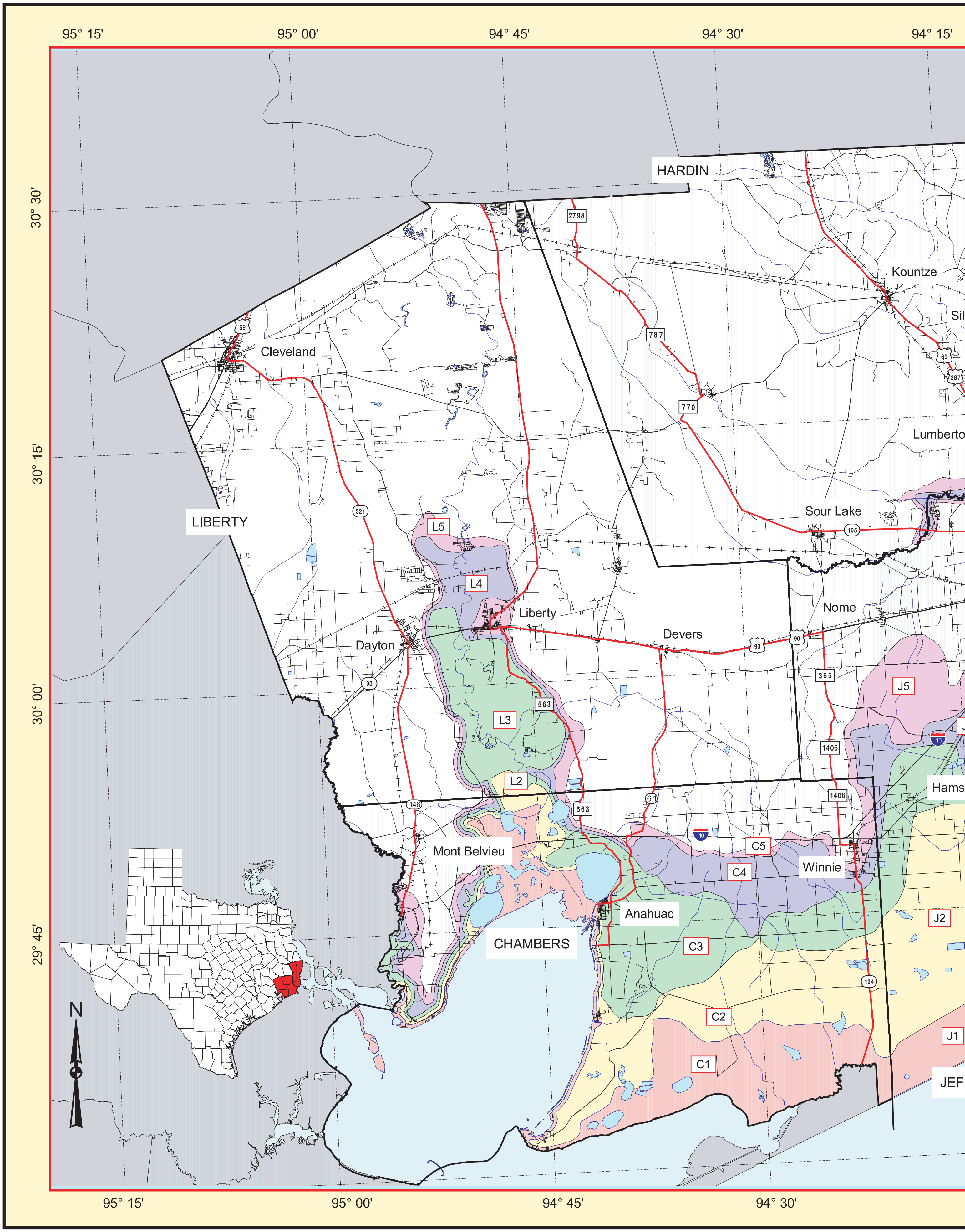
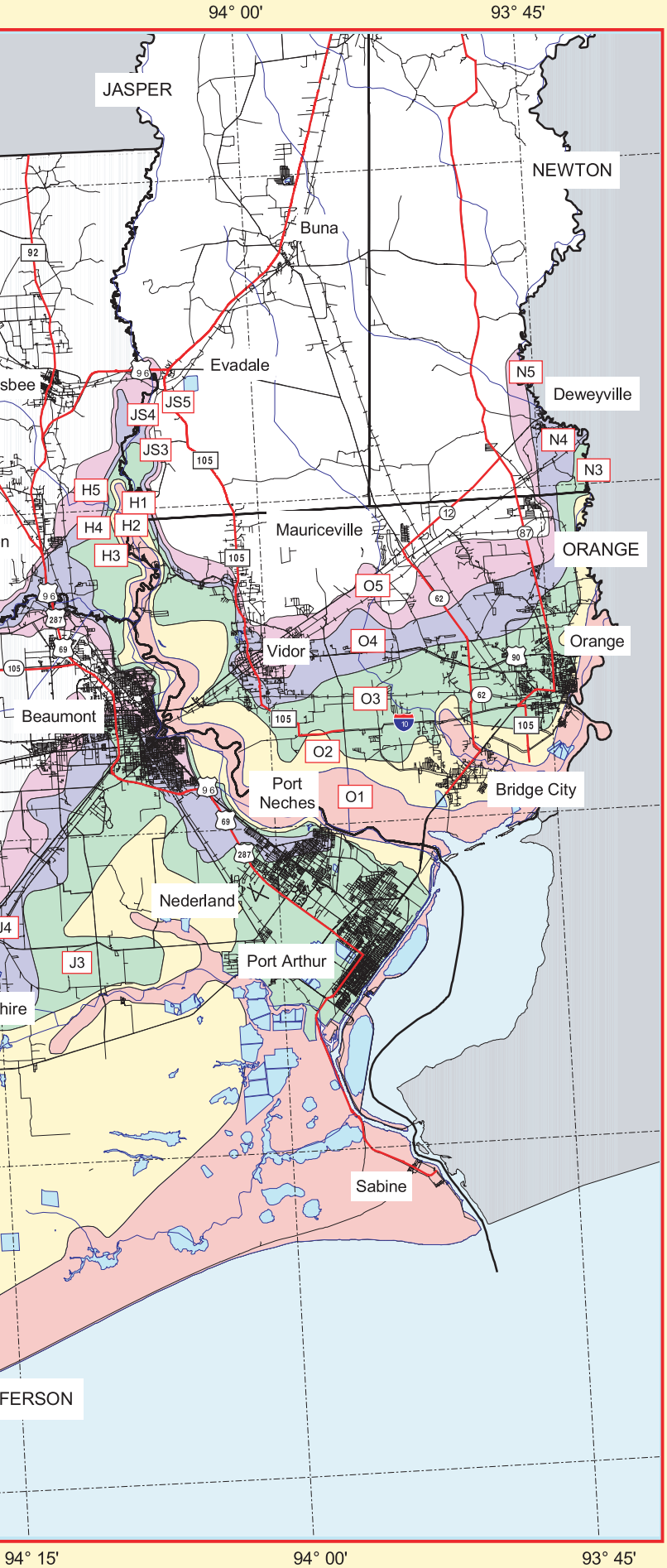


Hazard Reduction & Recovery Center, Texas A&M University, http://hrrc.tamu.edu Texas Division of Emergency Management, http://w

Lake Sabine Study Area

7 0 7 14 Miles



Saffir-Simpson Scale		Legend
Hurricane Category	Windspeed (MPH)	
1	74-95	Evacuation Routes
2	96-110	County Boundary
3	111-130	Risk Area 1
4	131-155	Risk Area 2
5	>155	Risk Area 3
		Risk Area 4
		Risk Area 5

Risk Area numbers correspond to hurricane categories. For example, in the event of a Category 3 hurricane, Risk Areas 1, 2, 3 would be threatened.

What To Do When A Hurricane Threatens

Find the location of your home on the map and note the risk area where it is located. Plan to evacuate for any hurricane whose category is equal to or greater than the number of your risk area. Thus, those in Risk Area 5 need to evacuate only from a Category 5 hurricane, but those in Risk Area 1 should evacuate from all hurricanes.

If you live near a risk area boundary and are unsure of which risk area you are in, err on the side of caution. Assume that you are in the risk area that will be affected by a lower hurricane category (i.e., a risk area that has a smaller number and is nearer the coast). If you live in a mobile home in any of the five risk areas, plan to evacuate any time a hurricane threatens.

During a hurricane watch, listen to your radio or television constantly. The Emergency Alert stations for your area are KTRH 740 AM and KPRC 950 AM (Chambers Co.) and KLVI 560 AM and KFDM Channel 6 (all other counties). The NOAA Weather Radio Stations are 162.550 megahertz (Galveston), 162.400 (Houston), 162.500 (Lake Livingston), 162.475 (Beaumont) and 162.425 (Burkeville).

Begin evacuation preparations during the hurricane watch so you will be ready to leave when you receive a hurricane warning. If you will be traveling with young children, older family members, or people with special needs, consider leaving before you receive an official evacuation warning.

When local officials tell you to evacuate, do so immediately. Plan to take the nearest evacuation route (marked by a red line on the map), but be prepared to take an alternate route if your primary evacuation route is congested. Be sure to take plenty of bottled water and snacks with you because the trip may take longer than usual due to congested roads.

Identify a place to stay before you leave. If you plan to stay in a hotel or motel, call ahead to make reservations. If you need to stay in a public shelter, public officials in host cities will let you know where one is located when you arrive. Many hotels and most public shelters do not take pets, so make other arrangements if necessary.

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Your Family Hurricane Plan Checklist

STEP I: PREPARING A DISASTER SURVIVAL KIT

The most important thing you and your family can do in preparation for a hurricane is be able to survive on your own after the storm. This means having enough food, water, and other supplies to last at least three days.

You may want to consider storing enough supplies to last up to two weeks. Local officials and relief workers will be on the scene after a disaster, but they can't reach everyone immediately. Basic services such as electricity, gas, water, sewage treatment, and telephones may be cut off for days or weeks.

You should store your kit in a designated place at home and have it ready in case you need to leave your home quickly.

Basic Disaster Supplies Kit:

(Keep items in airtight plastic bags and put your entire disaster supplies kit in one or two easy to carry containers)

- Water: three day supply: one gallon per person, per day (see below for further details)
- Food: three day supply: non-perishable (see below for further details)
- Portable, battery-powered radio or television and extra batteries
- Flashlight and extra batteries
- First aid kit and manual
- Sanitation and hygiene items (moist towelettes and toilet paper)
- Matches and waterproof container
- Extra clothing
- Kitchen accessories and cooking utensils, including a can opener
- Photocopies of credit cards and other identification cards
- Photocopies of important papers and phone numbers
- Cash
- Prescriptions
- Other medical needs items: eye glasses, contacts, hearing aid batteries
- Items for infants: formula, diapers, bottles, pacifiers

It's important to maintain your disaster supplies kit on a regular basis so that it is safe to use when needed. Change stored food and water supplies every six months. Canned foods should be kept in a dry place and boxed food should be stored in tightly closed plastic or metal containers to extend their shelf life. Replace food with fresh supplies when they go bad.

Water:

You should store at least one gallon of water per person per day. More water may be required for children, nursing mothers, ill people, and in cases of a medical emergency.

The safest and most reliable water supply would be made up of commercially bottled water. The water should be kept in its original container and not opened until it is used. Observe the expiration date.

If you choose to bottle your own water, it is recommended that you use food-grade water storage containers from surplus or camping supply stores. If not, you can use two-liter plastic soft drink bottles. Avoid using any containers that have had juice or milk in them: they can foster bacteria growth. Also avoid using cardboard or glass containers.

Before storing water, thoroughly wash the containers with dishwashing soap and water. Sanitize the bottles by adding one teaspoon of non-scented liquid household chlorine bleach to a quart of water. Swish around the solution so it touches every surface of the bottle. Thoroughly rinse out the sanitizing solution with clean water.

Fill the bottles with tap water and close the bottles with the original cap. Store the bottles in a cool dark place. Replace the tap water every six months.

Food:

Food should be non-perishable. Avoid foods that will make you thirsty. Choose salt-free crackers, whole grain cereals, and canned foods with high liquid content.

Stock canned foods, dry mixes, and other staples that do not require refrigeration, cooking, water, or special preparation. Include a manual can opener. Remember special dietary needs.

STEP II: PREPARATIONS AT THE START OF HURRICANE SEASON

__ Know whether or not your family lives in a designated evacuation zone (see the maps in this book). If you do live in an evacuation zone, plan ahead of time where you will go and where you will stay.

__ Know your children's school emergency plan. Ask how the school will communicate with families during a crisis.

__ Find out your workplace evacuation and emergency plan.

__ Learn how to shut off utilities (such as water and electricity) in your home.

Preparations around your property:

- Permanent storm shutters offer the best protection for windows. A second option is to board up windows with 5/8-inch marine plywood.
- Roof clips or straps (fastening roof to frame structure) can help reduce roof damage.
- Trim trees and shrubbery around the home
- Clear clogged rain gutters
- Determine how and where to secure your boat
- Find a central room on the lowest floor of your home away from windows to serve as a shelter during the storm

Inventory/Records:

- Make copies of important documents: Insurance policies (Property, Life, Health, etc.), credit cards, identification cards, property deeds. Keep copies in your disaster supplies kit.
- Make inventory of personal property for insurance purposes
- Make video of your personal property – furniture, pictures, appliances, clothes, tools, etc.
- Consider storing important documents in a safety deposit box away from your home
- Have an emergency fund (savings account) that could be tapped into in a crisis
- Keep a small amount of cash in a safe place that can be quickly accessed during evacuation

Plan for Those with Special Needs:

If you or someone close to you has special needs, you may have to take additional steps for protection in an emergency. The following special needs should be considered: the hearing or mobility impaired, the critically ill, the single working parent, non-English speaking persons, people without vehicles, and people with special dietary needs.

A special needs person should register with the office of emergency management for assistance so that required help can be provided in a time of crisis. Create a network of contacts to aid the person in an emergency. Be sure each knows how to operate necessary equipment. Keep specialized items available, including extra batteries, oxygen, medication, and any other items that might be needed. Make provisions for medications that require refrigeration. In an apartment or high-rise building, ask management to make arrangements to help the person leave the building.

Sheltering Pets:

Plan ahead on where you will board your pets during a hurricane. Some emergency shelters do allow pets now, but only certain shelters. Check ahead with a local emergency management office or animal shelter on which shelters, motels or hotels will allow pets, and where boarding facilities are located. Be prepared to make sure your animal is properly identified and to take veterinary records with you to prove vaccinations are current if you are asked to evacuate.

Sheltering Larger Animals (such as horses or cattle):

Ensure all animals have some form of identification. Make available vehicles and trailers for transporting each type of animal. Be prepared to evacuate the animals if necessary. Ensure that destinations have food, water, veterinary care, and handling equipment.

STEP III: WHEN A HURRICANE THREATENS

__ Frequently monitor radio, TV, NOAA Weather Radio, internet or hurricane hotline telephone numbers for official bulletins of the storm's progress.

__ Fuel and service family vehicles.

__ Inspect and secure mobile home tie downs.

__ Prepare to cover all window and door openings with shutters or plywood.

__ Check prescription medicines — obtain at least a ten day to two week supply.

__ Store and secure outdoor lawn furniture and other loose, lightweight objects, such as garbage cans, garden tools, potted plants, etc.

__ Stock up on extra batteries for radios, flashlights, and lanterns and check for ample first aid supplies.

__ Get an extra supply of cash to last two weeks. Banks may be closed and ATM machines may not work after the storm.

__ Make sure you have a full disaster supplies kit (see list in Step I).

Plan to evacuate if you...

__ Live in a designated evacuation zone (see maps in this book). If so, you may be directed by local authorities to evacuate. Be sure to follow their instructions.

__ Live in a mobile home or temporary structure. Do not stay in a mobile home under any circumstances.

__ Live on the coastline or on an offshore island, or live near a river or in a flood plain.

__ Live in a high-rise building. Hurricane winds are stronger at higher elevations.

If you are evacuating:

__ Disconnect utilities (including phone and electricity) as a precaution to prevent further damage.
Electricity: remember to shut off individual circuits before shutting off the main circuit breaker.
Gas: turn off gas at each appliance but do not turn off main gas line to the house.

__ Leave early and if possible, during daylight hours.

__ Notify neighbors and family members outside of the warned area of your evacuation plans.

__ Stay with friends or relatives or at a low-rise inland hotel or motel outside of flood zones. Leave early to avoid heavy traffic, roads blocked by early flood waters, and bridges made impassable due to high winds.

__ Hurricane shelters will be available for people who have no other place to go. Shelters may be crowded and uncomfortable, with no privacy and no electricity. Do not leave your home for a shelter until government officials announce that a particular shelter is open.

What to bring to a shelter:

__ First-aid kit, medicines, baby food and diapers, cards, games, books, toiletries, battery-powered radio, flashlights, extra batteries, blankets or sleeping bags, identification, valuable papers (insurance) and cash.

__ Pets: remember that only certain emergency shelters will allow pets. Keep veterinary records with you to prove vaccinations are current.

If you are staying in a home:

(Reminder! Only stay in a home if you have not been told to leave. If you ARE told to leave, DO SO IMMEDIATELY.)

__ Make sure all windows and doorways are covered by hurricane-proof shutters or 5/8-inch plywood

__ Turn refrigerator to maximum cold and open only when necessary.

__ Turn off utilities if told to do so by authorities. Turn off propane tanks. Unplug small appliances.

__ Stay inside your home at all times and away from windows and doors.

__ If you lose power, use flashlights rather than candles or open flames to move around in the darkness.

If winds become strong:

__ Take refuge in an interior room, closet, or hallway on the lowest floor away from doors or windows. Take a battery-powered radio, a NOAA Weather Radio and a flashlight with you.

__ Lie on the floor under a table or another sturdy object.

__ Close all interior doors. Secure and brace external doors. Keep curtains and blinds closed.

__ If you are in a multiple-story building and away from the water, go to the first or second floors and take refuge in the halls or other interior rooms away from windows. Interior stairwells and the areas around elevator shafts are generally the strongest part of a building.

NOTE: Be alert for tornadoes which often are spawned by hurricanes. Also, if the "EYE" of the hurricane should pass over your area, be aware that the improved weather conditions are only temporary and that the storm conditions will return with winds coming from the opposite direction sometimes in a period of just a few minutes.

STEP IV: AFTER THE STORM

__ Stay in your protected area until announcements are made on the radio or TV that the dangerous winds have passed. Stay off the streets unless absolutely necessary.

__ If you have evacuated, do not return home until officials announce your area is ready. Remember, proof of residency may be required in order to re-enter the evacuation areas.

__ Be aware of the surroundings when returning as extreme damage could render a familiar landscape unrecognizable.

__ If your home or building has structural damage, do not enter until it is checked by officials. Do not enter your home if you smell gas, floodwaters remain around the building, or if authorities have declared it unsafe. In a damaged home, have the electrical system checked out by an electrician before turning it back on. If water pipes are damaged, turn off the main water valve. Check with authorities before using any water as it may have become contaminated during the storm.

__ Beware of outdoor hazards such as downed power lines and any water they may be lying in, poisonous snakes driven from their dens by high water, weakened bridges, washed out roads, weakened limbs on trees and/or damaged overhanging structures.

__ Do not use the telephone unless absolutely necessary. The system is usually jammed with calls during and after a hurricane.

__ Guard against spoiled food. Use dry or canned food. Do not drink or prepare food with tap water until you are certain it is not contaminated with flood waters. Throw out any food, water, or supplies that have been contaminated or come in contact with flood waters.

__ When cutting up fallen trees, use caution, especially if you use a chain saw. Serious injuries can occur when these powerful machines snap back or when the chain breaks.

__ Call your insurance agent. Take video or still pictures of damaged property. Keep records of your repair and clean up costs.

Coping with post-disaster stress:

__ Maintain a normal family and daily routine, limiting responsibilities on yourself and your family.

__ Seek help from professional counselors for yourself and your family if needed. Talk to someone about your feelings even though it may be difficult. Make sure to get help for your children as well.

__ Use existing support groups of family, friends, and religious institutions.

__ Take steps to promote physical and emotional well being such as healthy eating, rest, relaxation, and meditation.

NOTE: These lists are not intended to be all-inclusive. You must decide what supplies are best suited for you and your family's survival. These list contain only suggestions for your consideration.

Emergency Manager Contacts

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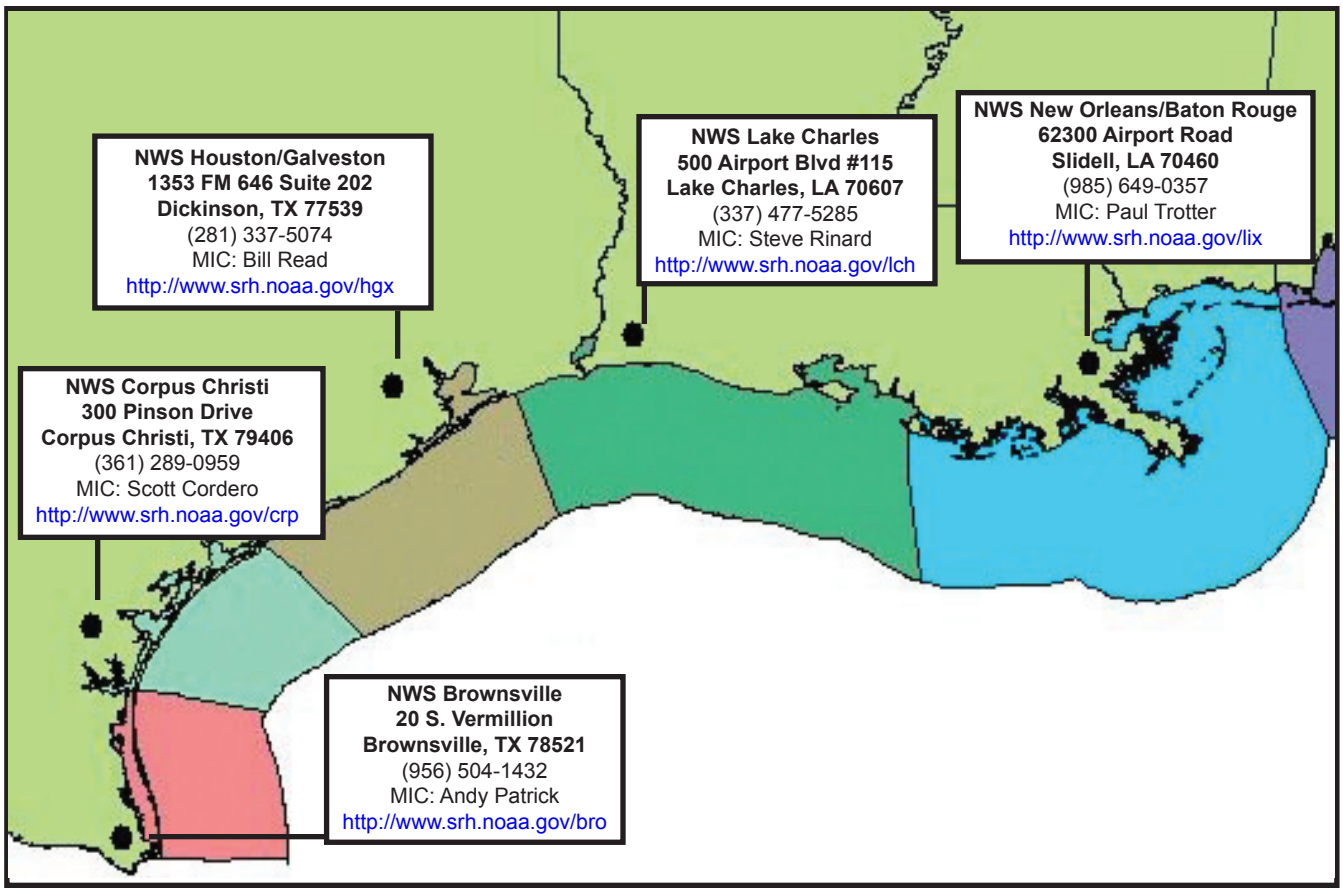
Regional National Weather Service Offices



Hurricane Preparedness and Weather Sites on the Internet

Tropical Prediction Center
National Hurricane Center
http://www.nhc.noaa.gov

NWS Southern Region Headquarters
http://www.srh.noaa.gov

Storm Prediction Center
http://www.spc.noaa.gov

Historical Hurricane Tracks
http://hurricane.csc.noaa.gov/hurricanes/index.htm

Interactive Weather Information Network - IWIN
http://iwin.nws.noaa.gov/

EMWIN Houston
http://houston.emwin.org

Dr. William Gray's Hurricane Forecasts
http://hurricane.atmos.colostate.edu/forecasts

Federal Emergency Management Agency
http://www.fema.gov/hazard/hurricane

Harris County Office of Homeland Security and Emergency Management
http://www.hcoem.org

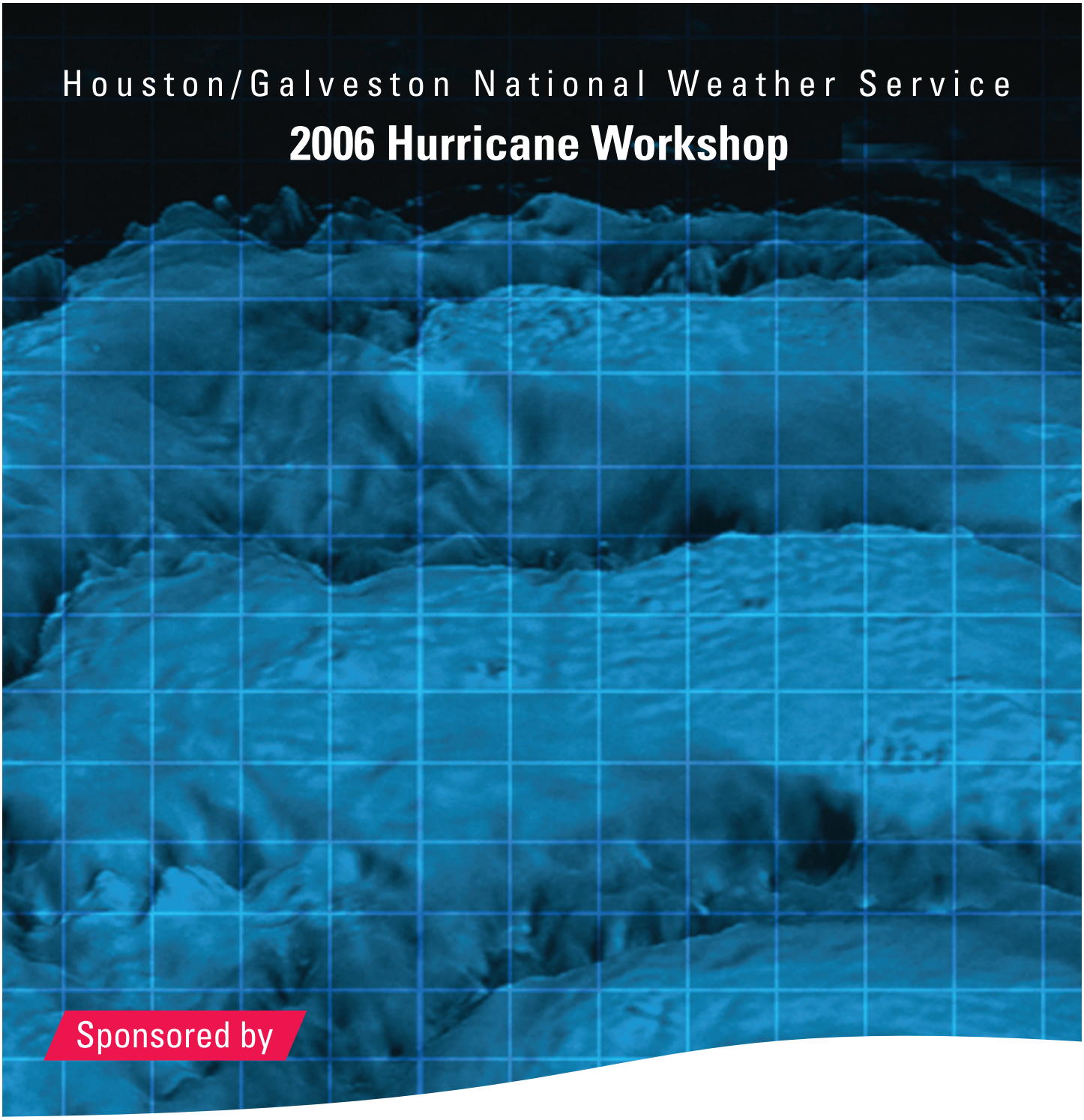
City of Houston Office of Emergency Management
http://www.houstontx.gov/oem/hurricane.html

Galveston County Office of Emergency Management
http://www.gcoem.org

American Red Cross
http://www.redcross.org/services/disaster

Houston/Galveston National Weather Service

2006 Hurricane Workshop



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